ROGERS

Convair TRAVELER

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FOREWORD

The selection and application of sealants in the manufacture of Convair-Liner 340 aircraft are discussed in this issue. The February 1, 1951 issue of the Traveler covers sealants and adhesives used on Convair 240's. In all applications, compounds should be used as directed by the manufacturer.

ON THE COVER

Bob Kingett, artist, illustrates some of the standard methods for applying sealants . . . brush, putty knife, pressure flow and hand caulking guns.

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C O N V A I R
A DIVISION OF GENERAL DYNAMICS CORPORATION
(SAN DIEGO)

SEALANTS
(Adhesives, Coatings, Sealers)

Sealants are playing a more and more important part in the fabrication of aircraft. They were used extensively in early aircraft in the construction of fabric and wood surfaces. Today, their usage is much more varied. They seal fuel tanks against leakage; bond porous or non-porous materials to themselves, to each other, and to metal; join irregularly contoured parts, or smoothly adhere sheet metals over large areas; fill the pores, plug the holes, and seal the joints of units so that liquids and gases cannot escape.

Generally speaking, sealants are used either to join surfaces (commonly called adhesives); to cover surfaces (coatings); and to bridge surfaces (sealers). Since an adhesive, coating, or sealer may serve more than one function at the same time, the term "sealant" is used generally to cover all three.

The advantages of sealants in the fabrication and construction of aircraft are many. They weigh less than most metal fasteners; they withstand the corrosive action of chemicals, solvents, and severe exposure; provide protection against abrasion and shock; combine surface protection with safety; protect and preserve highly polished finishes during production; they are resistant to aromatic fuels, oil, moisture, or corrosive chemicals; they endure throughout the service life of the product.

Some sealants are mixed with a fast-drying solvent to provide the right consistency for easy application. The volatile solvent dissipates, leaving a hard or pliable surface, as desired.

Other sealants do not require accessibility to air for drying. This type sealant may be used to lay a bead along the inside of a lapped seam, between faying surfaces, inside fuel tank areas. Curing is accomplished by means of an accelerator to provide the right consistency for application. Usually, these sealants must be kept refrigerated after mixing, since temperature and humidity have a marked effect on mixed sealers. The application of heat will accelerate the cure of these materials.

Sealants are compounded of synthetic and natural rubbers or resins. The rubber-compounded sealants are usually found in the adhesives and sealers; the resin-compounded sealants in coatings. Synthetic rubber compounds are superior to natural rubber sealants because of their superior resistance to petroleum fuels and lubricants, heat, oxidation, sunlight, and natural aging.

In the application of sealants, several requirements must be met.

1. *The surface must be properly prepared.* Sealants cannot be bonded to a surface that is wet, oily, or dirty. Adhesion is more effective on bare metal or on surfaces that have been anodized, phosphatized, or otherwise chemically treated. Some sealants are not compatible with a painted surface, since they have a tendency to lift or attack the paint.

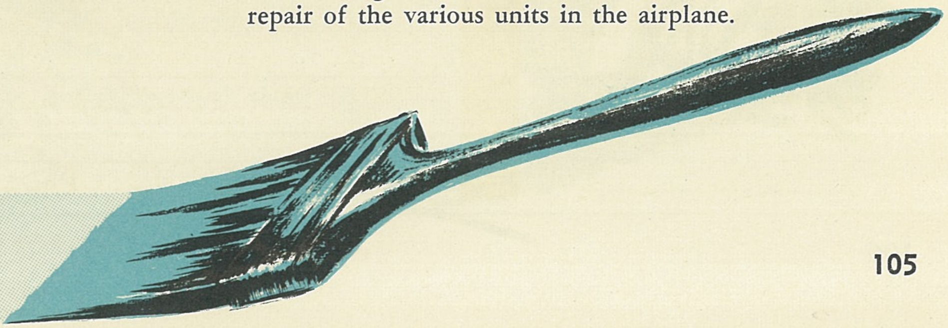
2. *Selection of proper sealant.* The proper sealant for each application is indicated on the blueprint, a determination that is made after careful analysis of all production and service conditions to which the sealant will be subjected.

3. *Method of application.* Many types of standard equipment are available for the application of the sealant. Equipment should be thoroughly cleaned before and after use.

4. *Mixing.* Manufacturers' instructions for mixing should be carefully observed because some sealants become too viscous to handle a short time after mixing. They will, however, stay workable for several hours if kept refrigerated.

5. *Flammability and toxicity.* Many sealants are flammable and/or toxic. Some require precautions against fire during storage and use. Any precautions prescribed by the manufacturer should be carefully followed.

The following table lists the recommended sealant used during manufacture and for maintenance and repair of the various units in the airplane.



FUSELAGE

MATERIAL	USAGE	*APPLICATION
EC-750	For sealing fuselage seams against internal pressure loss in high altitude flight. Alternate for EC-800.	Apply with pressure gun. Surface dries tack-free in 5 minutes. In 1 to 3 days, surface does not retain dust or dirt.
EC-795	For sealing openings on skin laps larger than 1/16″. Alternate for EC-800.	Apply with putty knife. Use no solvent with EC-795. Any change in low ratio solvent will materially reduce effectiveness.
EC-800	For weatherproofing and pressure-tighting from sta 109 to end of tail cone above floor.	Apply with brush or pressure gun. Volatile and flammable. Protect against fire during storage and use.
	On skin laps where gap does not exceed 1/16″.	
	For assembling lapped seams.	Apply 1/32″ coating to mating surfaces. Coat should cover entire area of lap.
	For coating bolts, screws, Hi-Shear rivets to be installed in pressurized areas.	Apply enough material to fastener so that it squeezes out and forms fillet around head.
EC-801	For weatherproofing and pressure-tighting fuselage from sta 0 to sta 109 around complete fuselage diameter; under floor area for entire length of fuselage; from sta 109 to sta 167 from floor level to stringer 30.	Apply with putty knife or notched scraper. Mix thoroughly with an accelerator before application.
	Wheel Well Structure: 1. Seam at attachment of well assembly to bulkhead. 2. Between clip and shear beam web. 3. Voids formed by joggles. 4. Around entire NLG dome door. 5. Tie-in of fuselage skin to lower angle of shear beam. 6. Attachment of nose wheel well to bulkhead 109.	Apply bead of sealer along inside edges of lap seam, using caulking or flow gun.
	Nose Jack Pad	Apply ribbon of sealer 3/16″ to 1/4″ wide along edge of door frame flanges and around entire periphery of frame.
171C62 Nylon Solution	For overcoating EC-801 where Skydrol is used.	Apply two brush coats over EC-801 in areas where Skydrol leakage may be problem.

* See page 108

FUEL TANK AREA

MATERIAL	USAGE	*APPLICATION
Fairprene sheet	For sealing metal-to-metal contacts within fuel tank area during manufacture.	Attach with brush coat of EC-776 on one side of metal contacting surface.
EC-776	For bonding Fairprene to metal.	
EC-776 with red aniline dye	Overcoat for EC-801 to add sealing protection and to facilitate inspection of sealed areas.	Three grams of red aniline dye to one gallon of EC-776 brushed over EC-801.
EC-870	For bonding Fairprene sheet to metal. Alternate for EC-776.	Apply brush coat to one metal contacting surface.
EC-801	For sealing tanks during manufacture.	Inject through special fittings along spar rails until sealant flows from void openings.
	For filleting around periphery of all fuel-tight corners after air test.	Apply fillet with flow or caulking gun.
	For resealing after a period of service.	Apply coat with putty knife or stiff bristle brush.
	For rivet replacement in fuel tank area.	Apply at junction of head and shank of rivet before installation.
	For temporary repair of fuel tank scupper.	Apply bead around scupper drain attachment.

WING

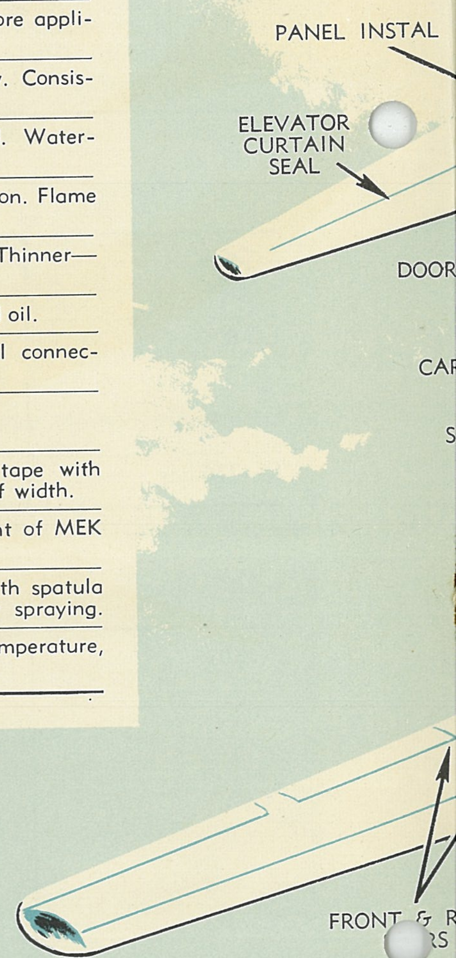
EC-801	Wing jack pad fitting.	Coat around bolts and fitting inside tank. Apply after air test.
EC-801	Wing lower surface access doors.	Coat contacting surface of dome nuts with thin coat, and rivet dome nut in place before sealer cures. Coat base of dome nut after installation with .06 coating.
EC-776	Overcoat for EC-801.	Apply after EC-801 has cured.

WING-TO-FUSELAGE SPLICE

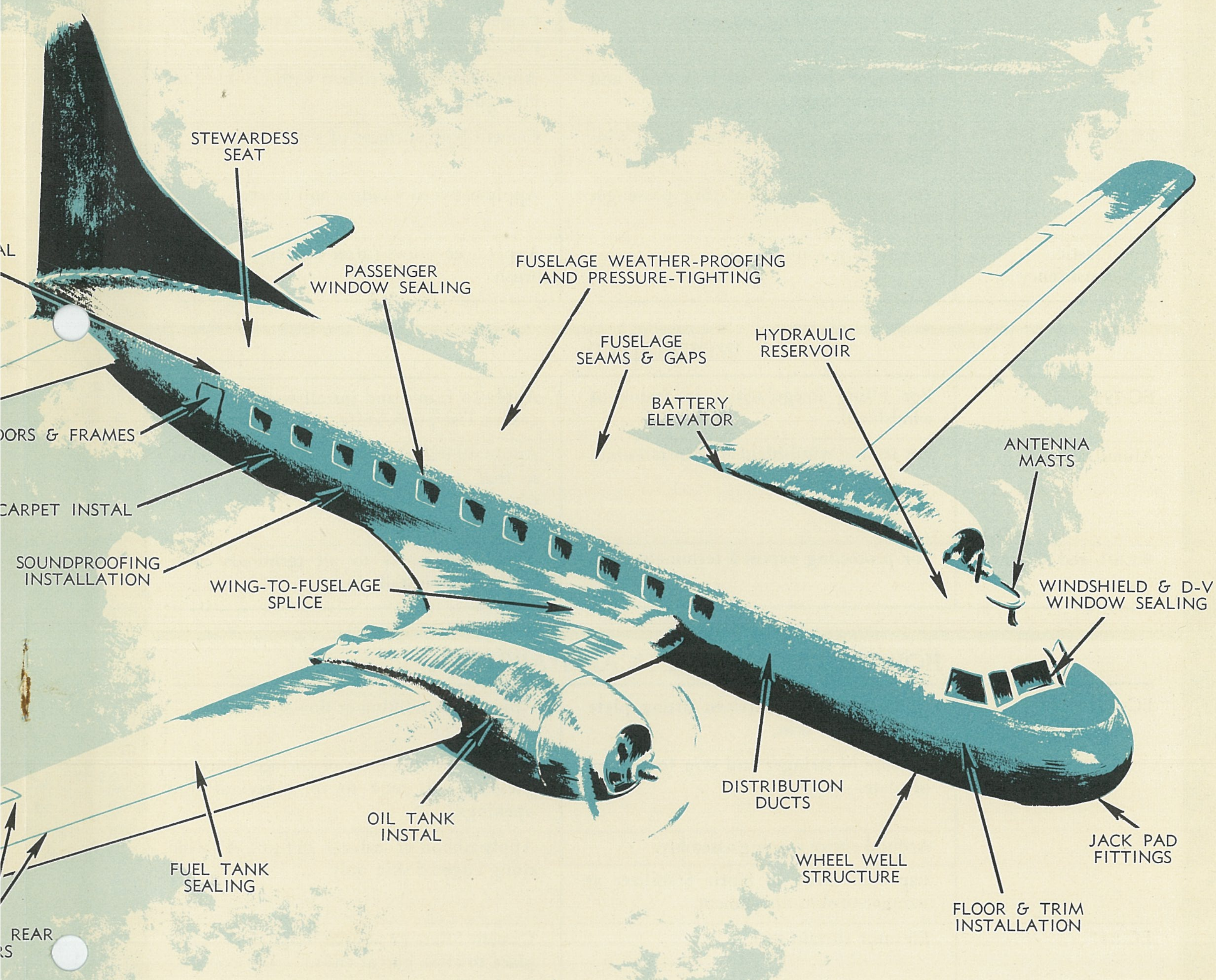
EC-801	Front and rear spars; wing upper surface splice plate.	After mating with fuselage, seal areas, using caulking or flow gun.
	Around entire spar web splice plate; gap between spar web and fuselage skin; seams formed by junction of upper wing skin to spar rail; junction of channel to fuselage skin.	Apply sealant in continuous ribbon.
	Around upper end of spar web tie-in angle; seam formed by fuselage skin and wing upper surface tie-in.	

* See page 108

SEALANT	MANUFACTURER	*SOLVENTS AND HANDLING
EC-524	Minnesota Mining & Manufacturing Co., Detroit, Michigan	Solvent—petroleum naphtha. Thermoplastic adhesive. Highly flammable in wet state.
EC-711		Solvent—toluene. Volatile and toxic. Use precautions against fire during storage and use.
EC-750		Solvent—methyl ethyl ketone and methyl isobutyl ketone. Volatile and flammable.
EC-776		Solvent—methyl isobutyl ketone. Toxic and flammable.
EC-795		Solvent—methyl ethyl ketone. Volatile and flammable. Container stability limited to three months.
EC-800		Solvent—methyl ethyl ketone. Volatile and flammable.
EC-801		Non-flammable. Resistant to weather, water, petroleum, greases, oils, and solvents. Remove with stripping agents.
EC-833		Solvent — petroleum naphtha, distillation range 145-205°F. Highly volatile and flammable.
EC-847		Solvent—acetone. Fast-drying cement. Volatile. Use precautions against fire during storage and use.
EC-870		Solvent—toluol. Toxic, volatile, and flammable.
EC-897		Solvent—methyl isobutyl ketone. Strong adhesive for plastics. Volatile and flammable.
EC-1300	Minnesota Mining & Manufacturing Co., Detroit, Michigan	Solvent—methyl ethyl ketone, toluol, petroleum naphtha. Flammable, toxic, volatile.
Zinc Chromate Primer	Commercial	Fast drying—6 to 24 hours required before application of top coat.
Alumilastic	Parr Paint & Color Co. Cleveland, Ohio	Silver in color; putty-like in consistency. Consistency cannot be changed by mixing.
DC-4	Dow-Corning Midland, Michigan	Smooth colorless translucent compound. Waterproof, water-repellent, chemically inert.
Fairprene sheet	E. I. duPont de Nemours & Co. Wilmington, Delaware	Sheet stock of synthetic elastic composition. Flame resistant.
171C62	W. P. Fuller Co., 222 N. Ave. 23 Los Angeles 54, California	Resistant to Skydrol and hydraulic fluid. Thinner—butyl alcohol.
TL8198		Black lacquer. Resistant to acid, fuel, and oil.
1201 red glyptal varnish	General Electric Co. Pittsfield, Massachusetts	Insulating varnish for sealing electrical connections. Thermo-setting adhesive.
M20 Pliobond	Goodyear Tire and Rubber Co. Akron, Ohio	Strong adhesive. Toxic and flammable.
Permacel #50	Industrial Supply Co. New Brunswick, N. J.	Pressure-sensitive double-faced cotton tape with tensile strength of 40 pounds per inch of width.
Red analine dye	National Aniline Co. New York City, N. Y.	Powder form—dissolved in small amount of MEK before introduced into sealer.
214 Plastic Metal Sealer	Aviation Lubricants, 1921 India San Diego, California	Aluminum dust and plastic—applied with spatula in paste form—thinned with MEK for spraying.
PR1600	Products Research Co. Los Angeles, Calif.	Solvent—methyl ethyl ketone. High-temperature, pressure-resistant compound.



Principal Convair 340 Sealant Applications



DOORS AND WINDOWS

EC-801	Around door frames.	Apply ribbon of sealer 3/16″ to 1/4″ wide along edge of door frame flanges and around entire periphery of frame.
	Around periphery of diaphragm seal angle that attaches to door frame.	Apply continuous fillet with caulking or flow gun.
	Around periphery of door frame where it attaches to hinge in radius of frame.	
	Hinge half where it mates with exterior door skin.	Apply faying surface seal with caulking or flow gun.
	Hydraulic equipment access door.	Cement door seal to reinforcement plate.
	Bottom access door installation.	Cement door seal to door frame. Cement seal to door.
EC-800	Passenger window angle-to-skin and angle-to-stringer faying surfaces.	Apply continuous ribbon with caulking or flow gun.
EC-833	For sealing pilots' direct-vision windows.	Cement both surfaces of seal.
DC-4	For sealing and lubricating passenger windows.	Apply between window and frame.
Alumilastic C-B consistency	For sealing windows.	Apply over screws (after tightening) with brush.

WINDSHIELD

EC-795	For filling irregularities in frame of windshield.	Apply to frame and install with neoprene gasket. Use putty knife.
Alumilastic	For sealing windshield after installation.	Apply sufficiently thick over face of gasket so that it will squeeze out around edges when windshield assembly is screwed down into place.
#1201 red Glyptal varnish	For protecting exposed terminals.	Apply two coats to all terminals with brush, after installation.

HORIZONTAL AND VERTICAL STABILIZERS

EC-800	For sealing void between fitting plate and fuselage skin.	Apply with caulking or flow gun.
	At base of stringer and skin for length of plate.	Apply sealant to interior surfaces since air pressure will tend to force sealant into openings.
	Around entire forging assembly.	Apply ribbon of sealer 3/16″ to 1/4″ wide along edge of skin only.
	Lap skin splice in Horiz Stabilizer at stringer-to-skin attachment.	
EC-847	Elevator curtain seal.	Cement fillers (2 at each hinge bracket) in place to close gap at ends.

ELECTRICAL

EC-801	For pressure-sealing electrical disconnect panels and harness pressure seals.	Apply 1/2″ coat on inboard surface surrounding seal mounting hole. Coat gaskets with thin film. Coat plate with thin film. After installation, apply bead around plate.
	Wing-to-fuselage disconnect panel gasket.	Apply 1/4″ coat on outboard surface surrounding hole; after installation, lay bead around panel to eliminate leakage of air pressure around pressure seals.
#1201 red Glyptal varnish	For protecting exposed terminals.	Apply two brush coats.
EC-1300	Wing-to-fuselage disconnect panel insulator.	Apply to insulator and panel so that bead is visible at mating edge of insulator and panel. Cement provides continuous adhesion around periphery of insulator.
TL8198	Battery elevator installation.	Coat all exposed surfaces.

ANTENNA INSTALLATION

EC-800	For sealing VHF antenna and transmission cable.	Apply brush coat to antenna and mounting pad surfaces.
	OMNI directional mast instal.	Cement around base of coaxial fitting on antenna mast to prevent pressurization leaks around connector fittings.
	ADF fwd and aft antenna loops.	Cover mating surfaces of antenna loop plate and skin.
	VHF mast antenna.	Install mast and doubler. Seal at installation.
	HF installation.	Seal surfaces between skin and doubler.
#214 Plastic Metal Sealer	HF antenna mast installation.	Bond antenna mast plate to doubler.
DC-4	HF communication antenna wire.	Coat wire (at installation) at tension unit and socket assembly.
Zinc Chromate Primer Paste	Liaison mast antenna.	Seal all joints between skin and mast with fillet of paste.
EC-870	OMNI directional mast instal.	Cement insulators together at each side of center line prior to installation.

DUCTING

MATERIAL	USAGE	*APPLICATION
Commercial adhesive tape	For sealing slip joints in side window defrosting ducts, and for sealing heat anti-icing ducts.	Wrap with one-inch adhesive tape.
EC-870		Cement between duct and between tape, and between layers of tape at overlap. Coat taped joint.
EC-870	Cabin pressure duct instal—wing center section.	Cement coupling to ducts. Cement sleeve to duct to prevent leakage.
	For bonding cabin distribution duct gasket to hatrack.	Cover mating surfaces.
	Heat vent and pressure duct.	Cement gaskets on either side of primary compressor check valve.
EC-800	Radio rack cooling venturi.	Seal duct cover-to-plate attachment.
EC-801	Compressor air supply duct.	Seal gasket and flange at duct housing.
PR-1600	For sealing hatrack support to distribution duct.	Cover mating surfaces.
	Pilots' vent riser.	Cement between mounting flange and duct.
Alumilastic	Compressor air supply duct deflector.	Install deflector with Alumilastic between deflector and skin. Wipe off excess.

INTERIOR EQUIPMENT

EC-870	Soundproofing.	Bond together batt and cover. Cement blanket around beltframes and to stringers so that blanket will flare out against trim angle.
EC-776		Cement pad on heat and vent duct to prevent duct and scuff panel from oil-canning.
EC-524	Lavatory partition assembly.	Cement bumper to partition assembly. Locate to suit door handle.
EC-833	Lavatory floor.	Bond floor covering to prevent leakage of liquids to under-floor areas. Turn up edges of floor covering approx .75 inch all around except in areas of door. Bond to vertical surfaces to obtain seal. Scallop floor covering as required to obtain fit. Cement in area of scallops to mitered joints and along bottom edge of coving.
EC-847		Bond Fiberglas sheet to sponge rubber pad. Thin cement to brush consistency. Coat both mating surfaces; allow to dry, and reactivate with heat and bond.
Industrial tape #50		Double-faced tape. Use under sponge rubber pad in strips not less than 12″ on centers.

* See page 108

INTERIOR EQUIPMENT (continued)

Alumilastic	Lavatory panel installation.	Use along entire horizontal edge of coving at floor. No compound must be visible after coving is installed.
Permacel #50 tape	Carpet installation.	Install carpet with double-faced tape between carpet and floor.
EC-833	Buffet floor.	Bond floor covering, and seal all corners, joints, and edges. Cement covering to floor and seal edges to prevent leakage of spilled liquids.
EC-847		Bond floor covering to Fiberglas. Thin cement to brush consistency. Brush both parts, allow to dry, and reactivate with heat.
EC-800		Attach sponge rubber pad. Seal all edges of pad.
Industrial tape #50		Attach Fiberglas to floor with double-faced tape. Use under Fiberglas in strips not less than 12″ on centers.
EC-897	Flight deck interphone tube.	Cement microphone stowage grommet to console.
	Pilots' compt trim installation.	Cement panel to defrosting duct and to trim panels.
EC-847	Pilots' Compt floor covering.	Seal and turn under edge of floor trim with cement.
Tape #480	Outboard radio rack curtain.	Use transparent tape as necessary to seal open spaces at cutouts for frame, harnesses, etc.
EC-833 Pliobond M20	Stewardess seat backrest.	Cement cover material to plate. Scallop around corners as required to prevent wrinkles. *Do not cement in area of rivet holes in plate.* Cement cap assembly to seat assembly linkage.

OIL SYSTEM UNITS

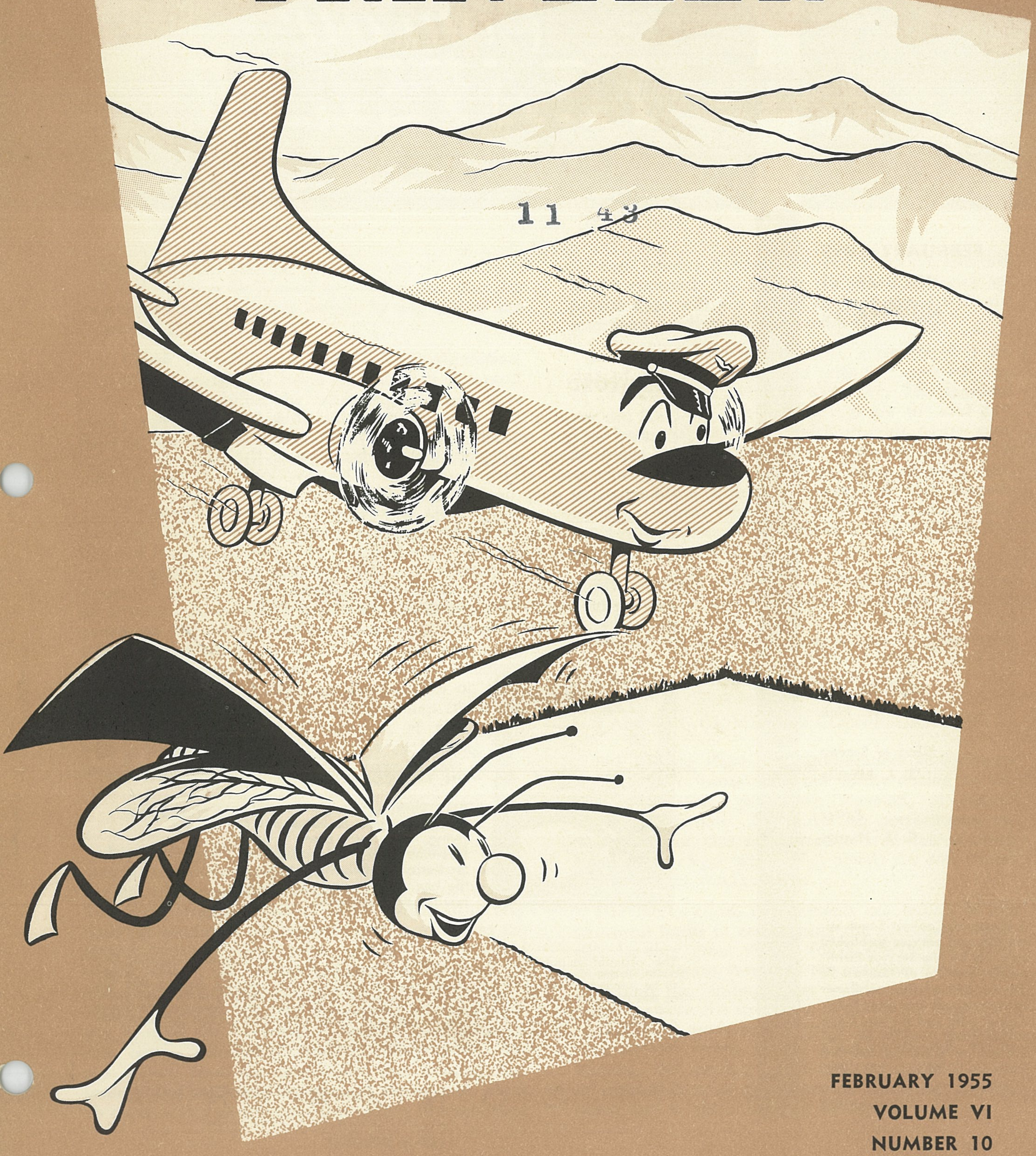
EC-711	Oil tank installation.	Attach cushion to nacelle saddle assembly.

HYDRAULIC UNITS

EC-801	For installing hydraulic reservoir.	Apply small bead around periphery of reservoir-to-pan contacting surface.
171C62		Apply two brush coats over EC-801 in areas where Skydrol leakage may be a problem.

Rogers

Convair TRAVELER



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FOREWORD

CAR 4b regulations, governing permissible operating weight, require a minimum rate-of-climb for the landing configuration, irrespective of the landing field length available. The available field length may limit the landing gross weight to a value that is less than the structural gross weight limitation or the climb performance gross weight of the airplane.

These limitations and requirements, plus information on weight and balance, are discussed in detail in this issue.

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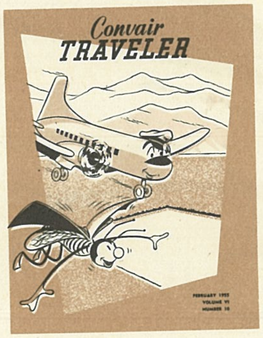

ON THE COVER

According to some areodynamicists, the bee is incapable of flying. The bee doesn't know this—nor does the artist—for on the cover Bob Kingett shows the bee, as well as the Convair, having no problems.

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CONVAIR
A DIVISION OF GENERAL DYNAMICS CORPORATION
(SAN DIEGO)

Landing Weight Limitations

The maximum landing gross weight of Convairs 240 and 340 may be limited to a value less than the maximum structural gross weight by any one of the following factors:

1. *Climb Performance—Approach Configuration.* This climb parameter is based on operating at takeoff power on one engine, the other engine inoperative with propeller feathered, landing gear retracted, and flaps in the approach position. A minimum rate-of-climb is required, irrespective of available landing field length.

2. *Landing Performance — Intended Destination.* Landing distance is based on the transition (airborne) distance from a theoretical 50-foot obstacle to ground contact, plus stopping distance. The total distance is presented as 166% of intended destination (143% of alternate destination) to allow consideration for overshoot and runway surface conditions. "Obstacle" speed is specified as 1.3 V_{SO} (where V_{SO} equals the landing configuration stall speed); "contact" speed is based on 1.2 V_{SO}. Ground deceleration or stopping distances are based on complete flap retraction initiated at 0.9 V_{SO}. The variation of stall speed with gross weight has a direct effect on landing field length requirements as described later in this article.

APPROACH-CLIMB CONFIGURATION

Approach-climb configuration performance is required to insure adequate climb ability during single-engine, gear-retracted landing pattern maneuvering. The single-engine approach-climb requirement may limit the maximum permissible landing weight at the airport altitude, irrespective of the landing field length. The CAR 4b performance requirement for this configuration is a rate-of-climb equal to .04 V_{SO}^2, where V_{SO} equals the zero thrust stall speed in miles per hour of the "associated" landing configuration. The term, "associated" landing configuration, has significance from the standpoint that landing flap settings and approach flap settings are related. CAR 4b requires that an approach flap setting be established for each landing flap selected, and limits the selection of the approach flap so that the stall speed with approach flaps will not exceed the stall speed with the associated landing flaps by more than 10%.

In view of these requirements, a landing flap setting of 40° should be used with an approach flap of 24°; 28° with 17°; 22° with 13°. The standard landing and approach flap settings are 40° and 24°. The lesser flap settings, which provide better rate-of-climb, are used when a maximum payload is desired at high altitude fields where landing field length is not a problem. However, if high altitude landing distance becomes critical with reduced flap settings, compromise in approach and landing flap selection is required.

The approach configuration climb speed is selected on the basis of speed for best rate-of-climb, subject to minimum control speed (V_{MC}) limitations. V_{MC} represents the airplane minimum control speed with one engine inoperative, propeller feathered, and the other engine operating at takeoff power.

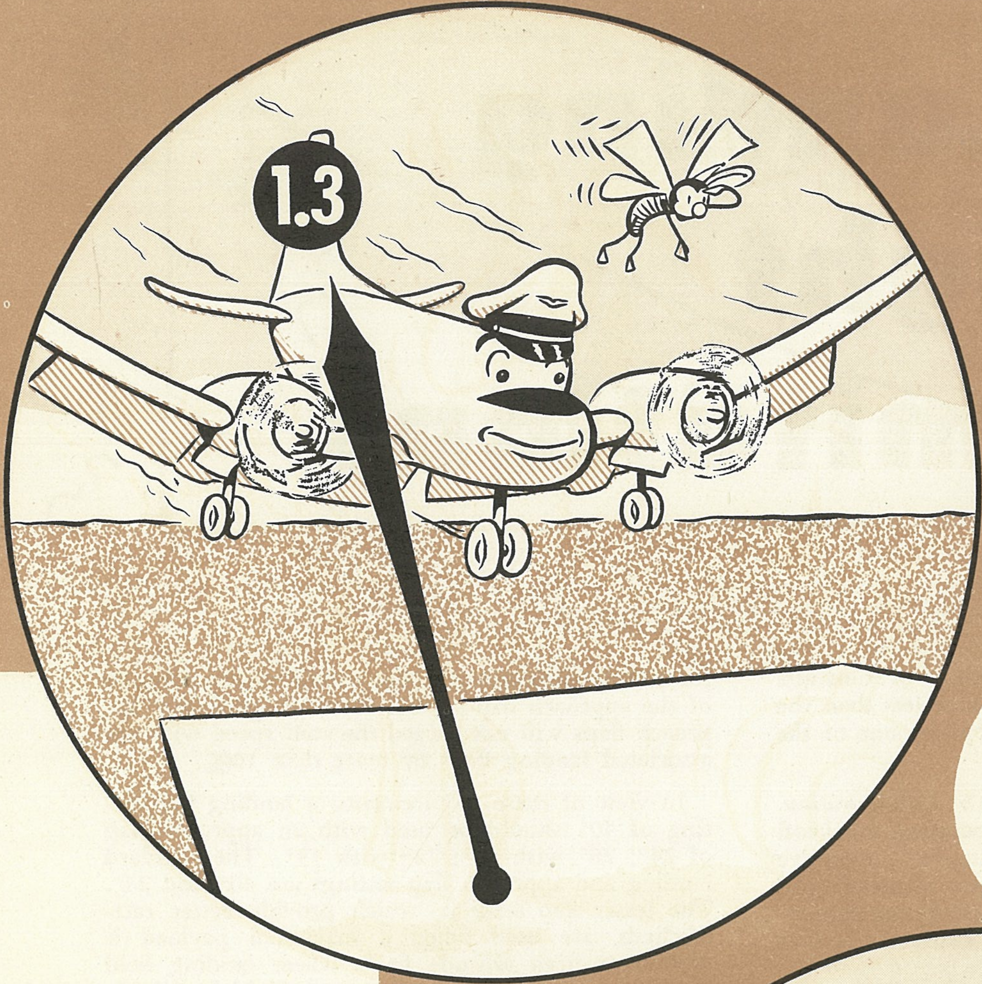
LANDING CLIMB-OUT CONFIGURATION

The landing climb-out configuration performance is required to insure climb-out ability during an all-engines-operating, gear-down wave-off, or balked landing operation. The CAR 4b performance requirement for this configuration is a rate-of-climb equal to .07 V_{SO}^2 where V_{SO} equals the stall speed in the subject configuration.

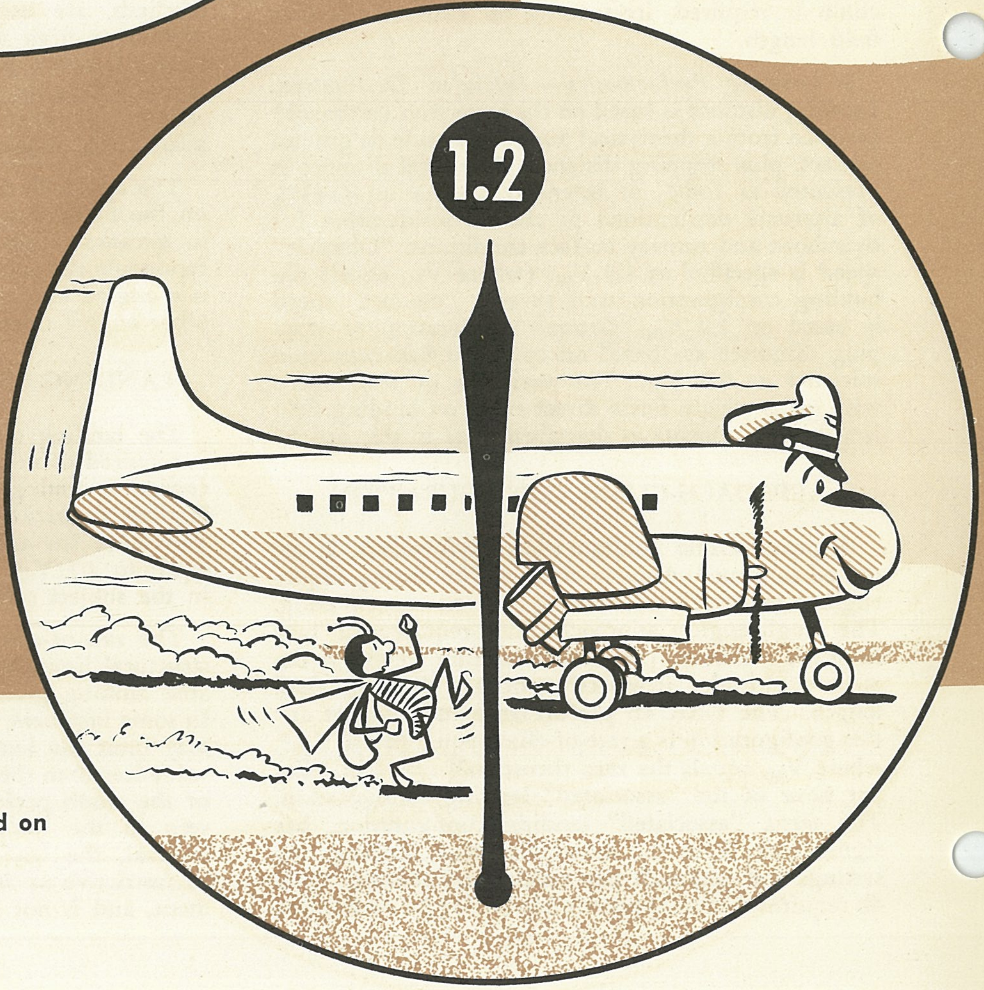
The rate-of-climb requirements are second to the structural limits in establishing the maximum allowable landing gross weight for a specific condition. In some instances, however, the available field length may limit the landing gross weight limitation to a value less than the structural gross weight limitation, or the climb performance gross weight. As can be seen in the charts in the CAA approved Flight Manual, the landing climb-out requirement is not as restrictive as is the approach climb-out requirement, and is not a limiting factor.

The

Now that we are familiar with the considerations of climb performance limits as assessed against landing gross weight, let us consider the actual landing itself and how CAR 4b requirements are employed to insure a safe landing operation.



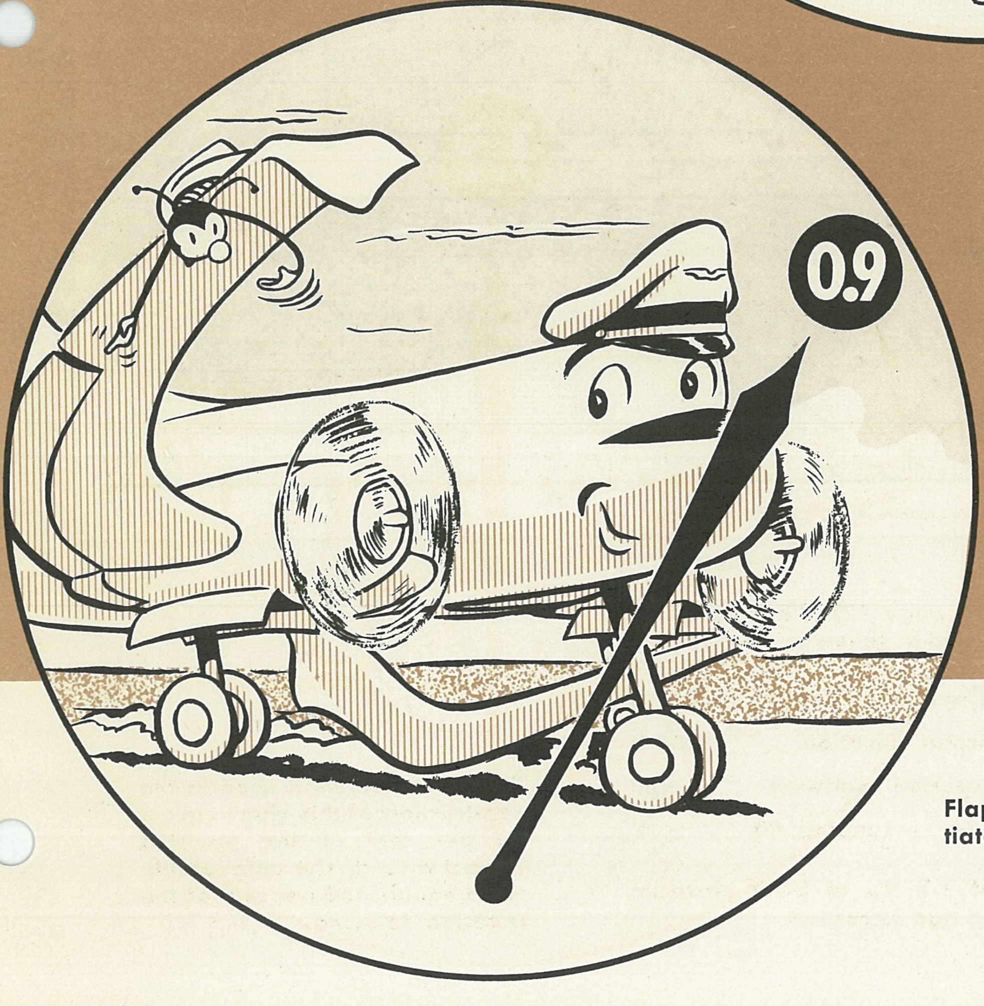
Obstacle speed is specified as 1.3 V_{so}



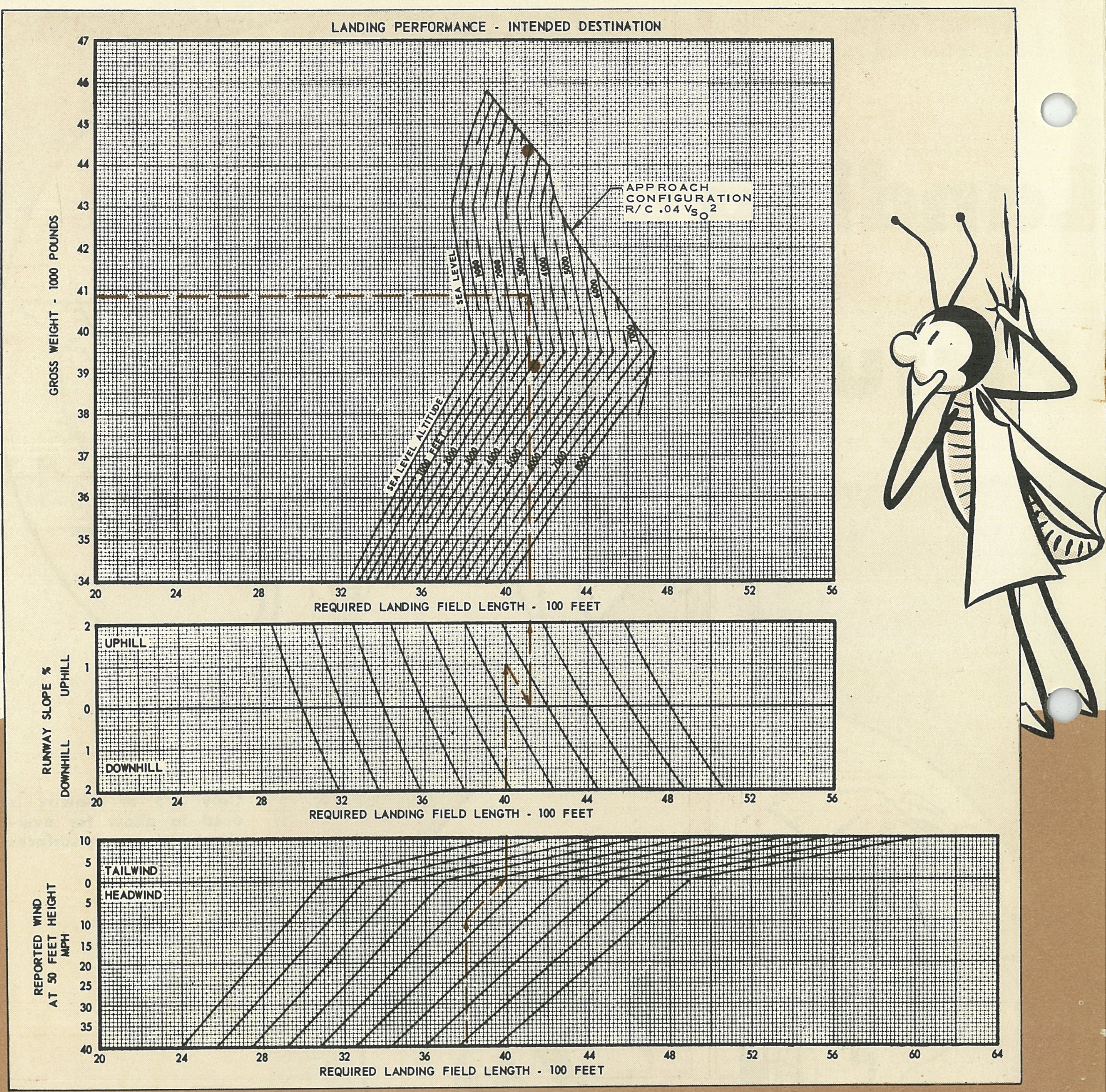
Contact speed is based on 1.2 V_{so}

Landing Picture

Only 3/5 of runway is used to allow for overshoot and runway surfaces



Flap retraction is initiated at 0.9 V_{so}



Utilizing the example at the top of page 121, find maximum allowable landing gross weight under following conditions:

Hard surface runway — maximum available length			**3800 ft**
Standard atmosphere		**Airport elevation**	**3000 ft**
Runway slope	**1% uphill**	**Reported headwind**	**10 mph**

Wing flaps — Approach 24° — Landing 40°

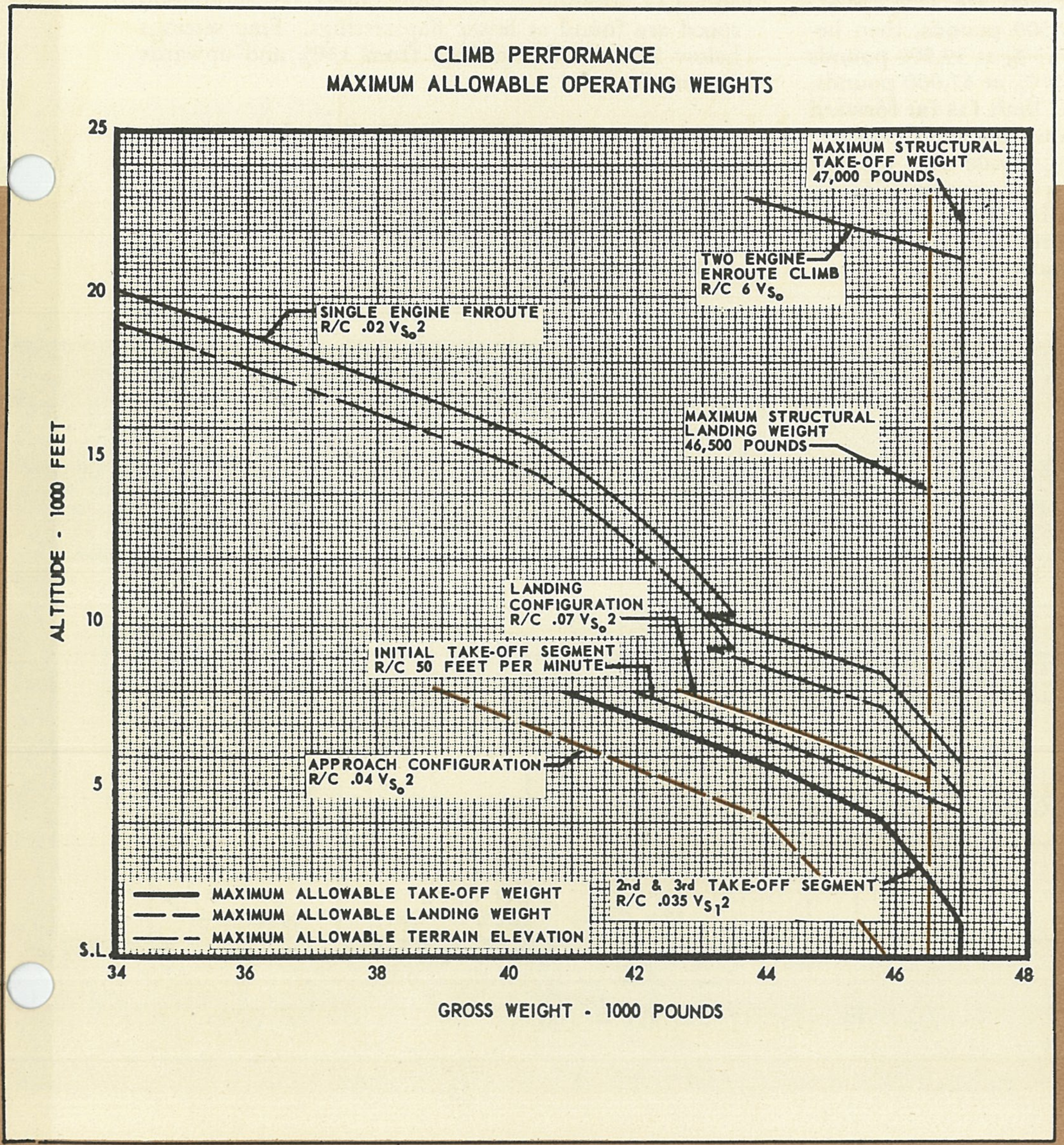
Distances determined on basis of 1.3 V_{so} at 50-ft obstacle; 1.2 V_{so} at contact; 0.9 V_{so} at wing flap retraction.

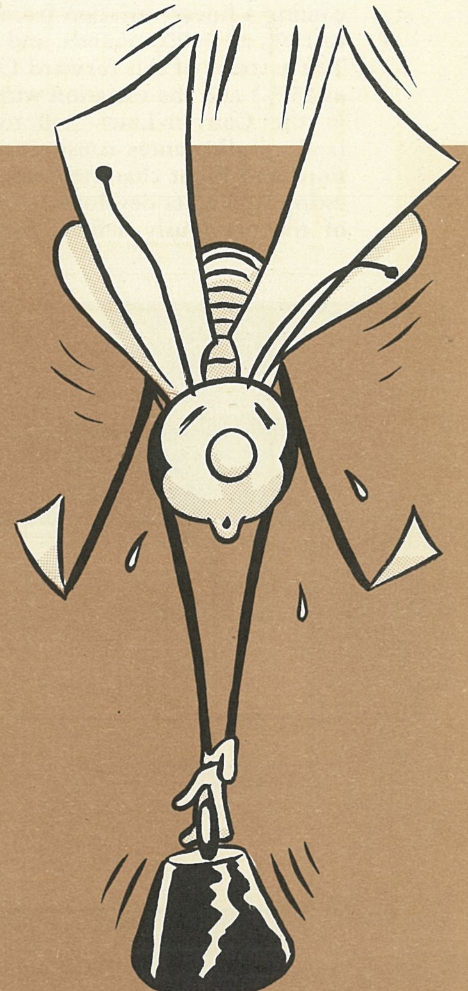
Note:
The favorable wind used in the construction of this chart equals 50 per cent of the reported headwind. The unfavorable wind equals 150 per cent of the reported tailwind.

TO FIND THE MAXIMUM ALLOWABLE LANDING GROSS WEIGHT

1. Enter bottom of chart at the given landing field runway length of 3800 feet.
2. Go vertically up to the 10-mph headwind line.
3. From this point, parallel wind nomogram lines to the 0 mph headwind line.
4. From this point, which falls on the 4000-foot runway length line, proceed vertically to the 1.0% uphill slope line.
5. From this point, parallel slope nomogram lines to the zero slope line.
6. From this point, which falls on the 4120-foot runway length line, proceed vertically to the 3000-foot altitude line and from this intersection proceed horizontally to the gross weight scale, and read the maximum allowable landing gross weight of 40,900 pounds for a maximum forward CG location of 14.6% MAC, or 39,100 pounds for a maximum forward CG location of 13% MAC, or 44,300 pounds for a maximum forward CG location of 17.7% MAC.

Note: For CG limits, see chart on page 124.





The approach configuration climb limitation presented as the maximum allowable landing weight parameter, also appears as the limit performance envelope on the landing performance chart. (See note at bottom of chart on page 120.)

To return to the subject landing performance chart, much inquiry has been received regarding the rather "errant" curve characteristics displayed on some of these series of charts. The cause of this characteristic is included in the following discussion.

As previously mentioned, landing distances are based on measured distances whose values depend on various speeds related to the zero thrust stall speeds (1.3 V_{SO}, 1.2 V_{SO}, and 0.9 V_{SO}). The zero thrust stall speeds are in turn determined with the center of gravity position, which is most unfavorable in achieving a minimum stall speed. For the Convair-Liner 340 and other conventional type aircraft this, of course, means the maximum forward CG parameter determined by the manufacturer's selection, or the CAR 4b limits of controllability and trim.

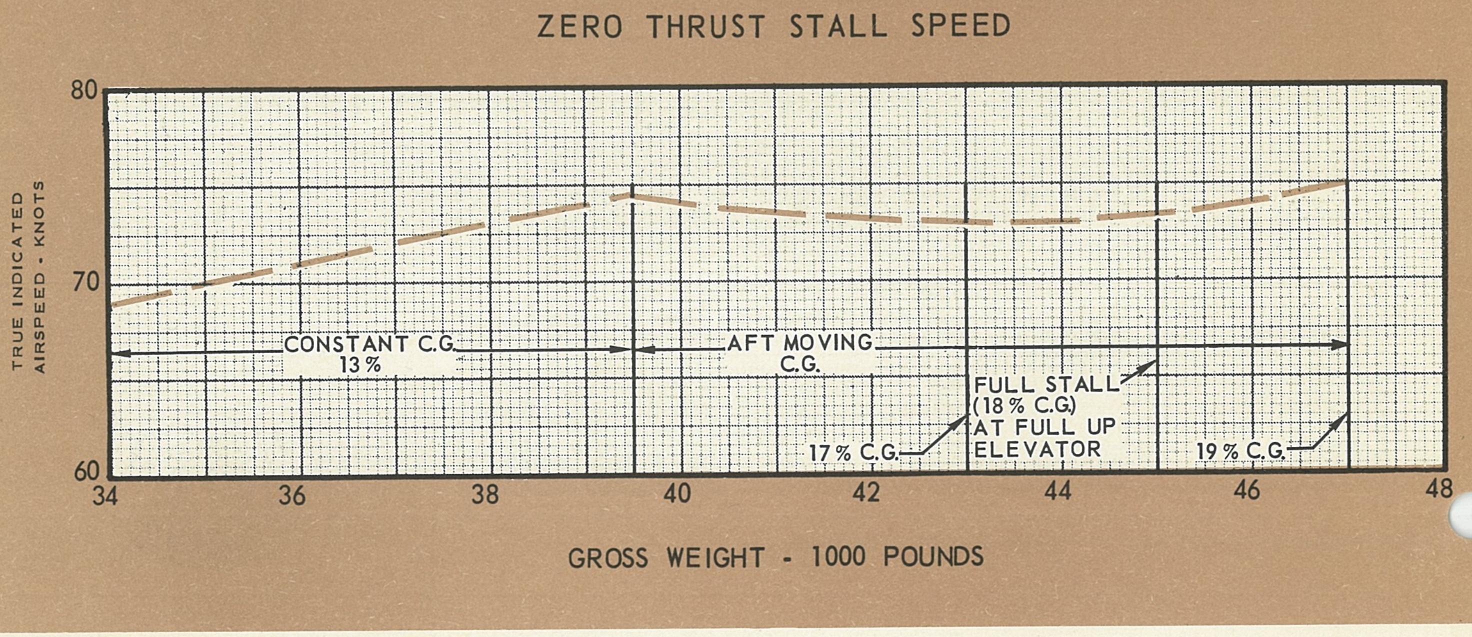
The most forward takeoff and landing center of gravity limits for the Convair 340 are 13% MAC for all gross weights up to 39,500 pounds, then becoming a linear variation from 13% at 39,500 pounds to 17% at 43,000 pounds, and 19% at 47,000 pounds. The extreme of this forward CG limit (as far forward as 13%) and the variation with weight was developed in the Convair-Liner 340 to provide the greatest landing allowances consistent with structural limitations and flight characteristics. However, some interesting sidelights developed as a result of the selection of the previously defined forward CG limit.

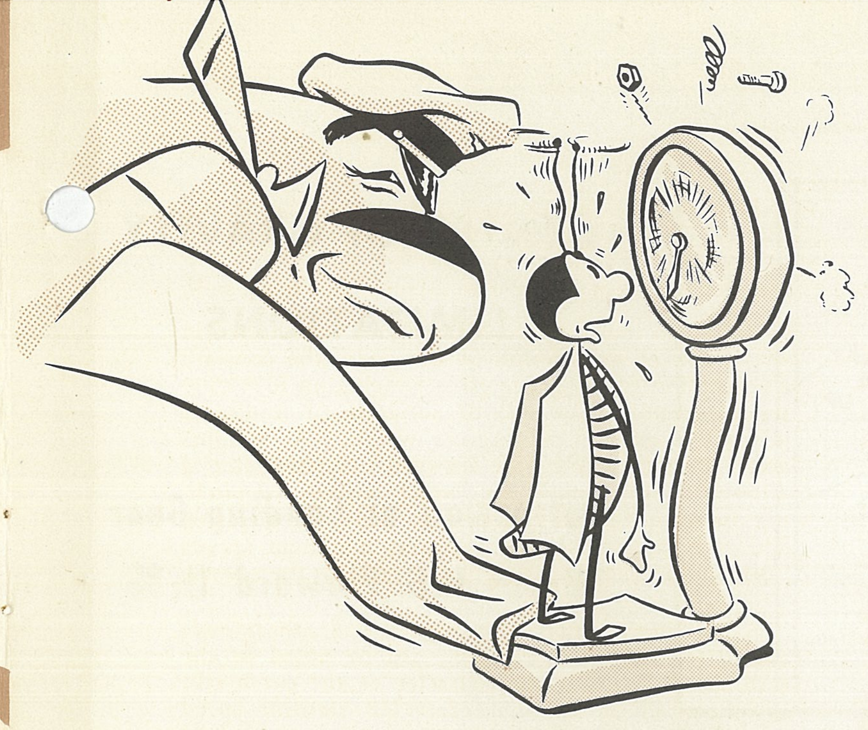
First of all, the Convair 340 cannot be stalled (under CAR 4b stall speed determination methods) at the 13% CG location with full flaps. Full UP elevator produces a minimum airspeed but not a stall.

As shown in the Flight Manual and as indicated in the graph at the bottom of the page, the constant CG location of 13% for gross weights up to 39,500 pounds results in a smooth variation of minimum attainable airspeed with gross weight. At weights above 39,500 pounds, the forward CG parameter is allowed to shift (move aft) which reduces the pitching moment that is required to stall the airplane. This, in turn, results in reducing minimum speeds faster than increasing weight can increase the speeds.

A shift in the slope of stall speed at 43,000 pounds and 17% MAC CG location, can be noted in the stall speed line, but the character of the curve still is influenced by minimum full UP elevator speed instead of stall speed. At 45,000 pounds gross weight and 18% MAC CG location, a full CAR-defined stall can be obtained, and the balance of the curve above 45,000 pounds is a function of gross weight and CG location. The same effects of minimum speed are found at lesser flap settings. Flap settings below 22° at CG locations from 13% and upwards are unaffected.

It is therefore evident that CAR landing distance, dependent as it is on stall speed for its ultimate values, must vary accordingly with stall speed and assume graphic presentation much the same as that of a zero thrust stall speed plot. The similarity becomes quite evident.





Weight and Balance

Weight estimation and control, and location of the airplane center-of-gravity are functions performed by the weight and balance engineer. Due to the effects of weight and balance on aircraft performance, stability, and control, this function is one of great importance and should not be underestimated.

The center of gravity of the airplane is that point about which the static airplane weight is balanced. Since fuel, lubricants, and payload are variables for, and during, each flight, the center of gravity is also a variable. The allowable limits are generally established by the stability and elevator power of the airplane. Aft movement of the CG reduces the stability and hence is limited by the stability margin required for a safe and "easy to fly" airplane. As the loading is moved forward, stability is increased; however, a point is reached where forward loading is limited by elevator control power. The forward CG limit is generally fixed by the amount of elevator available for trimming the airplane at low speeds such as for landing.

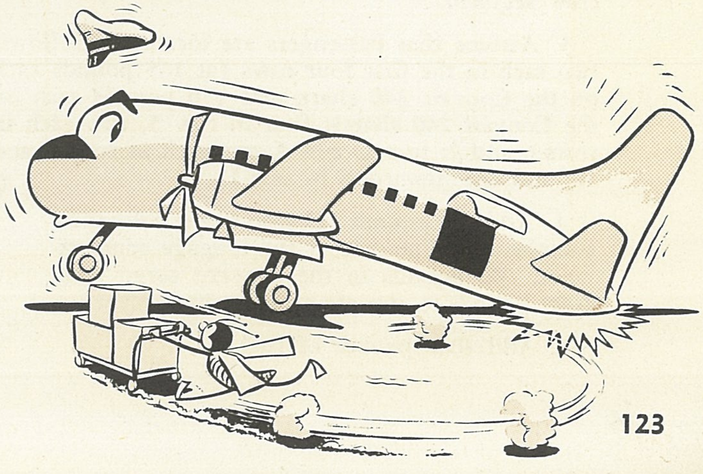
In the early design stages, the center of gravity is estimated from the weight and location of various component parts of the airframe, engines, and equipment. Prior to flight, the engineer's computations can be checked by actual weighing of the completed airplane. The weights registered at the suspension points (landing gear or jack points) are checked to determine not only the basic weight but also the actual center of gravity. From the center of gravity corresponding to the operating weight empty and the allowable CG travel, the airline operator can determine proper loadings for the airplane.

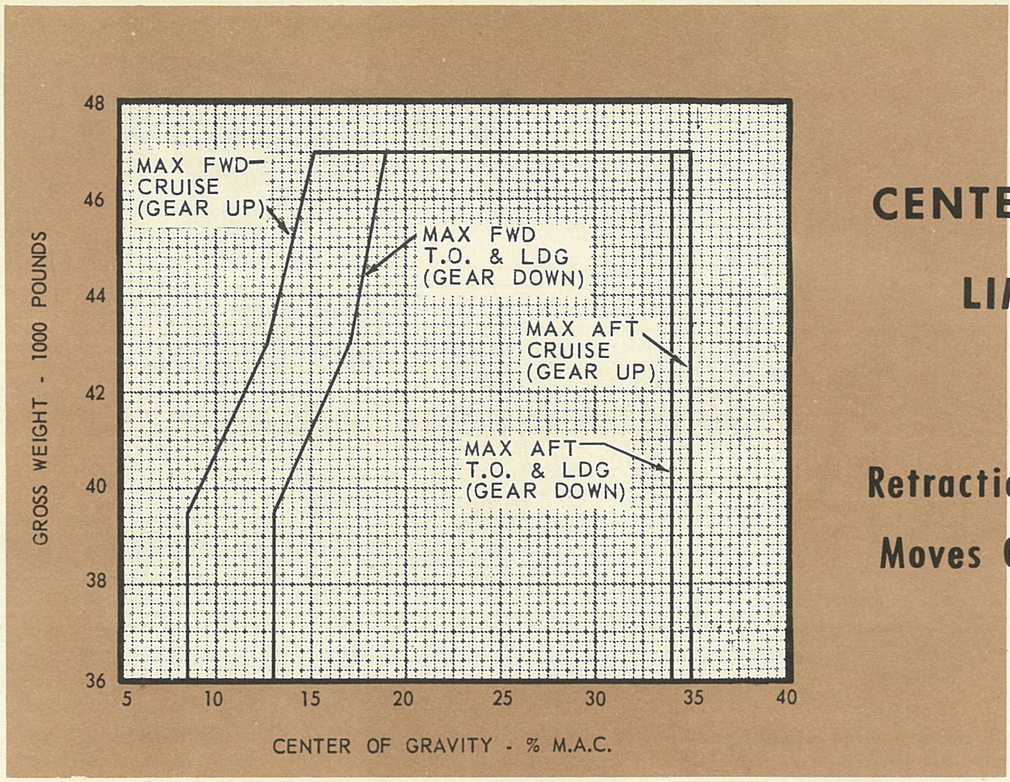
The gear-down forward and aft CG limits are the extreme center of gravity range allowable for takeoff and landing, while the gear-up forward and aft CG limits are the extreme range allowable during flight to permit passenger movement. The CG limits are determined during the CAA certification flight tests by demonstration of compliance with the prescribed stability requirements. For the Convair-Liner 340, CAA-approved forward limits gear down are 19% at 47,000 pounds; 17% at 43,000 pounds and 13% at 39,500 pounds. The gear up forward CG limit moves forward 4½% and the aft CG limit moves aft 1% over the gear down limits.

• • • • • •

Canadian Pacific Airlines has devised a simple-to-use chart for determining the center of gravity location on their Convair-Liner 240's. A similar chart has been prepared for the Convair 340 in which a simple problem has been worked. The weight distribution portion of the chart has been reproduced for the benefit of all Convair-Liner operators; the load digest portion, which is not shown, may be drawn up to suit each airline's particular operation.

To use the Weight and Balance Manifest on pages 125 and 126, it is first necessary to establish the zero index and the total empty weight (T.E.W.) index. The 0 index for Convair-Liner 340's has been established at 373.76 by the following formula: (length of MAC x 20% MAC) + L.E. of MAC = 0 index, or 114.3 x .20 + 350.9 = 373.76.





CENTER OF GRAVITY LIMITATIONS

Retraction of Landing Gear Moves C.G. Forward 1½%

Once this figure has been established, application is simple. For example: if from an actual weighing the weight empty of the airplane is determined to be 36,000 pounds and the CG at this weight is 13% MAC (fuselage inch station 365.7), obtain weight empty (T.E.W.) index as follows:

$$\frac{13\%\ \text{MAC—0 index}}{10000}\ (\text{wt}),\ \text{or}\ \frac{365.7—373.7}{10000}\ (36{,}000)$$

equals —28.8.

1. Enter the chart at —28.8, and draw a line vertically downward to the first point of intersection with a diagonal line.

2. Draw a horizontal line in the direction of the arrow in the right-hand margin for the correct number of segments. Note that the stewardess will be shown as an extra passenger in the last row, if she is seated aft as on the Convair-Liner 340 and on some Convair-Liner 240's. On those Convair 240's where she is seated forward, she will be indicated in the crew segment.

3. Assume that passengers are located as follows: two each in the first four rows (at 165 pounds each on the Convair 340 chart, and 170 pounds each on the Convair 240 chart); four in row 5, two each in rows 6 and 7; four in row 8, two each in rows 9 and 10; and one stewardess in row 11.

4. Add 400 pounds of cargo in the belly compartment; 200 pounds in the luggage compartment; 600 pounds in the forward cargo area; 1000 pounds in the aft cargo compartment.

5. Add 4000 pounds of fuel.

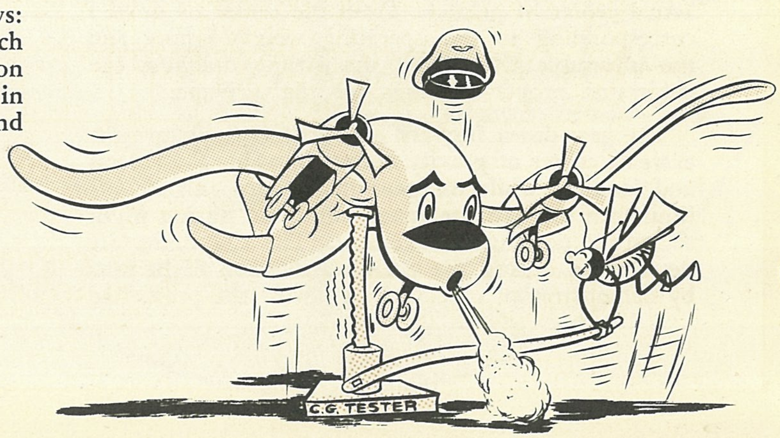
6. When these weights are added, draw a line down to the % MAC for the gross weight (total weight of airframe, passengers, cargo and fuel), to determine center of gravity, which in this case is approximately 26 per cent.

The fuel load for a given flight consists of two parts: 1), the expected burnout between takeoff and landing, and 2), the necessary reserve, plus additional fuel to reduce the number of stops at which refueling is required, if payload is not critical.

Estimation of the expected burnout should be made as accurately as practical. This value establishes the takeoff weight and thus the weight at landing for trip lengths under 60 miles, and for trips where the landing weight is restricted at the destination airport.

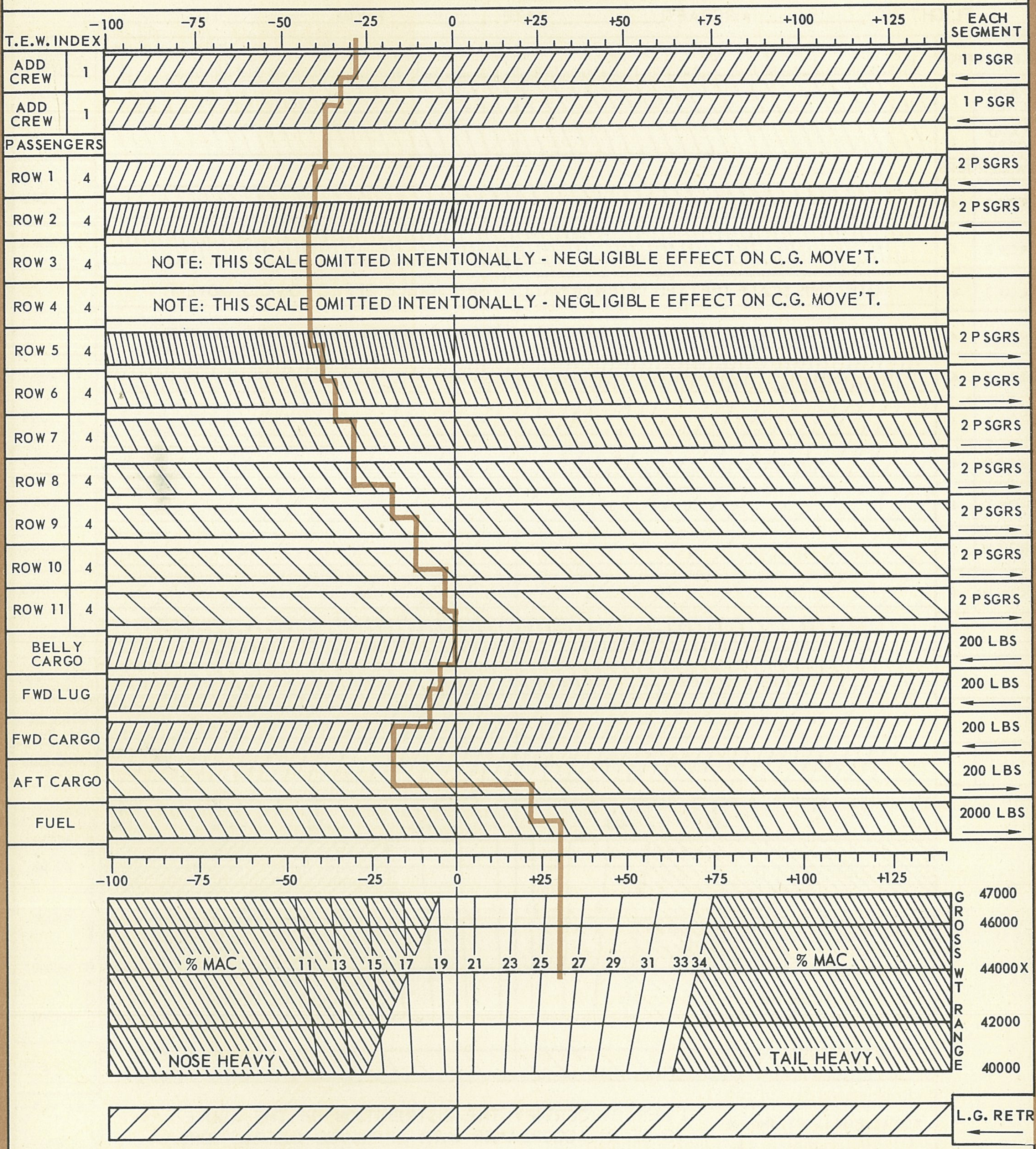
Note

The maximum allowable fuel unbalance between tanks is 300 gallons. This is an allowable in-flight condition, and the airplane should not be dispatched with this unbalance.



WEIGHT AND BALANCE MANIFEST

FLIGHT NO.__________ AIRCRAFT__________ DATE__________ FROM__________ TO__________



TOTAL EMPTY WT. INDEX

$$\frac{{}^{*}FS - 373.76}{10{,}000}\ (WT)$$

I HEREBY CERTIFY THE DISTRIBUTION OF THE ABOVE TO BE IN ACCORDANCE WITH APPROVED INSTRUCTIONS.

SIGNATURE ______________________________

*FUSELAGE STATION AT WEIGHT EMPTY CG

WEIGHT AND BALANCE MANIFEST

FLIGHT NO.__________ AIRCRAFT__________ DATE__________ FROM__________ TO__________

T.E.W. INDEX		−100 −75 −50 −25 0 +25 +50 +75 +100	EACH SEGMENT
ADD CREW	1		1 PSGR ←
ADD CREW	1		1 PSGR ←
PASSENGERS			
ROW 1	4		2 PSGRS ←
ROW 2	4		2 PSGRS ←
ROW 3	4	NOTE: THIS SCALE OMITTED INTENTIONALLY - NEGLIGIBLE EFFECT ON C.G. MOVE'T.	
ROW 4	4	NOTE: THIS SCALE OMITTED INTENTIONALLY - NEGLIGIBLE EFFECT ON C.G. MOVE'T.	
ROW 5	4		2 PSGRS →
ROW 6	4		2 PSGRS →
ROW 8	4		2 PSGRS →
ROW 7	4		2 PSGRS →
ROW 9	4		2 PSGRS →
ROW 10	4		2 PSGRS →
			200 LBS ←
			200 LBS ←
			200 LBS ←
FUEL			2000 LBS ←

−100 −75 −50 −25 +25 +50 +75 +100

			GROSS WT RANGE
% MAC	17 19 21 23 25 27 29 31	% MAC	40500
			40000
			38000
NOSE HEAVY		TAIL HEAVY	36000
			34000

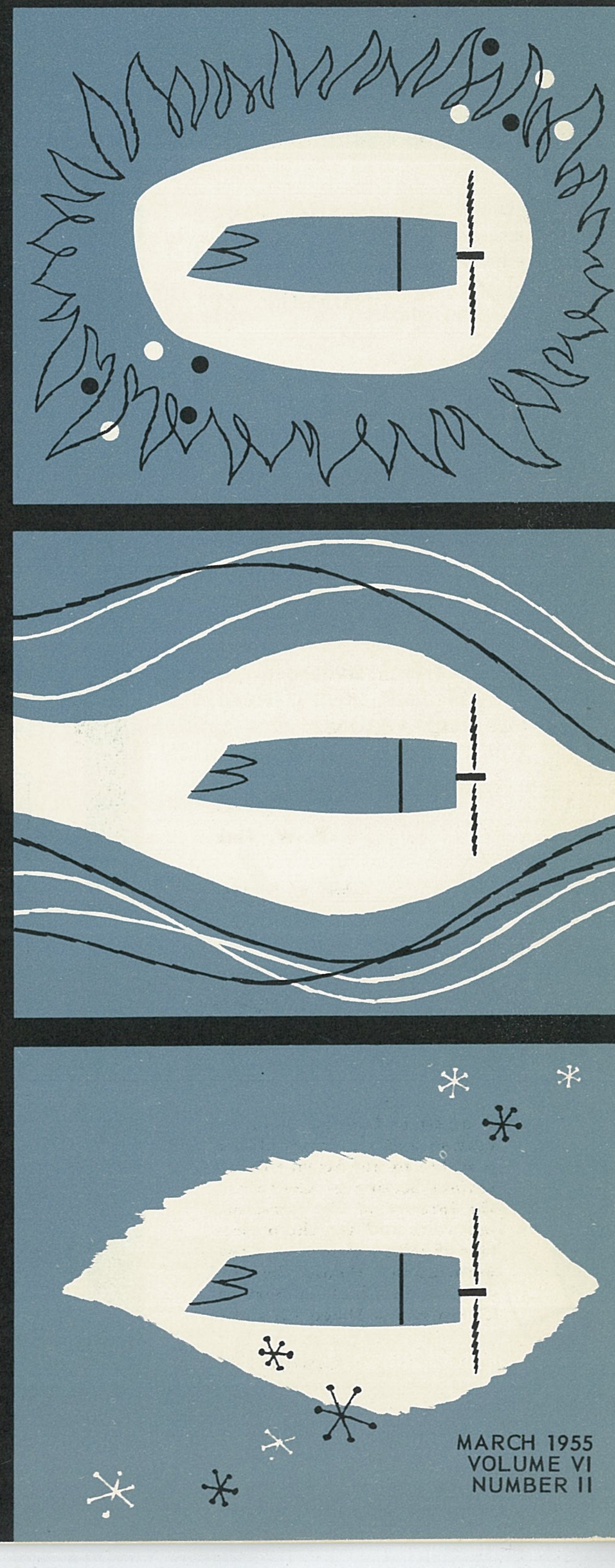
L.G. RETR ←

TOTAL EMPTY WT. INDEX

I HEREBY CERTIFY THE DISTRIBUTION OF THE ABOVE TO BE IN ACCORDANCE WITH APPROVED INSTRUCTIONS.

SIGNATURE ____________________

Convair TRAVELER



MARCH 1955
VOLUME VI
NUMBER 11

Convair
TRAVELER

MARCH 1955
VOLUME VI
NUMBER 11

FOREWORD

Power Plant management, as the name implies, provides sound engine operating practices under varying conditions. Included in this issue is operation of the controls and instruments by which the pilot regulates performance of the engine. These are the procedures recommended by Pratt & Whitney, engine manufacturer, and are within CAR requirements, where applicable.

A subsequent issue will discuss propeller operation and control, cruise mixtures, and takeoff horsepower calculations.

ON THE COVER

It has been said, "The elements of art are all about us if we but had the wit to see them." Willis Goldsmith, artist, had a flash of wit about engines. He shows the pilot's satisfaction with engine operation, come heat, wind, or snow.

Chief Engineer
F. W. Fink

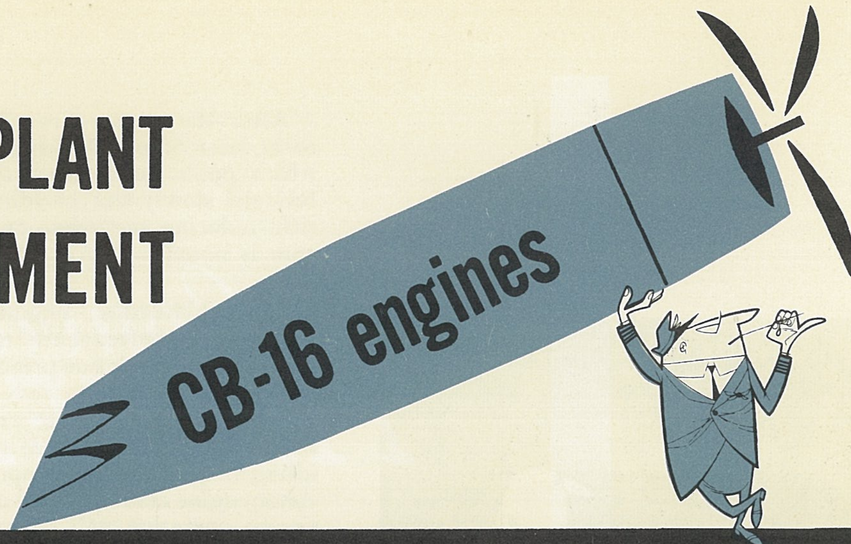
Chief of Service
J. J. Alkazin

Editor
G. S. Hunter

A digest of Convair-Liner operation and service published monthly by the Service Publications Section of Convair in the interest of Convair-Liner operators and for the promotion of sales and service. Communications should be addressed to Chief of Service, Convair, San Diego 12, Calif.

CONVAIR
A DIVISION OF GENERAL DYNAMICS CORPORATION
(SAN DIEGO)

POWER PLANT MANAGEMENT



Proper engine start practices preclude the possibility of engine fires during starting. Specific practices recommended by the engine manufacturer (P&W) are discussed. Step-by-step engine start procedures are not outlined, however, since each operator, with the approval of P&W, has set up standardized procedures to suit that airline's particular operation.

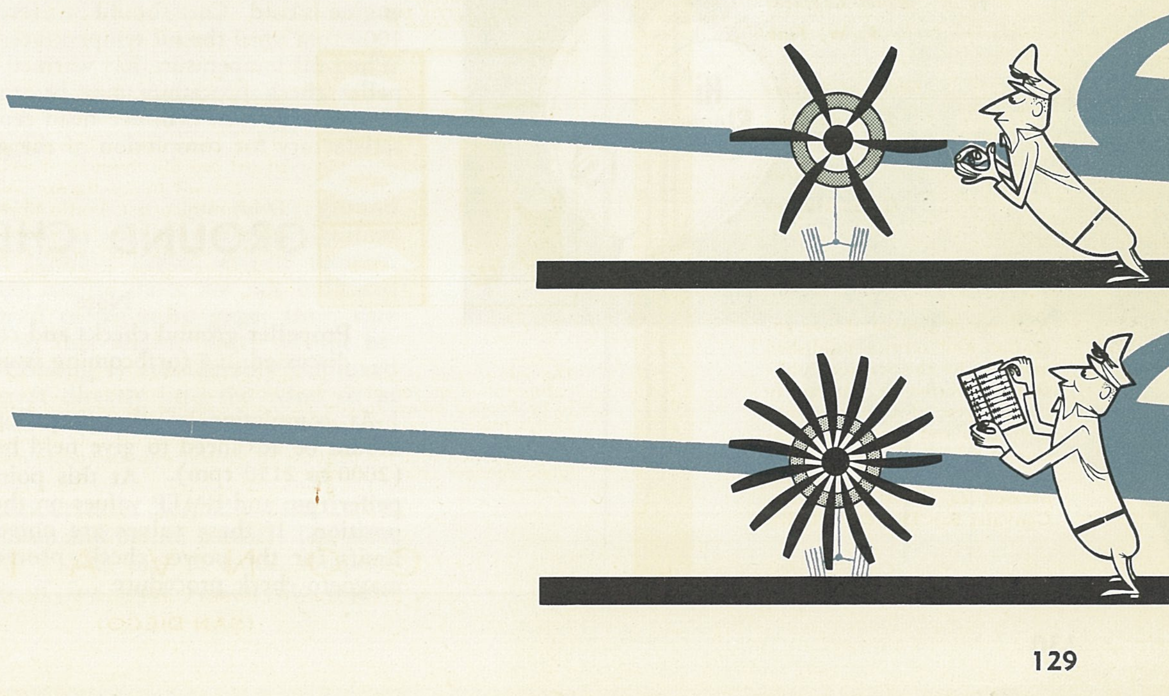
The R-2800 engine requires 300 to 350 amperes at 28 volts for starting. A ground power unit with 500-ampere capacity should sufficiently handle ground power requirements. Power units with low capacity may fail to start the engine and can cause damage to both the power unit and electrical system components.

The ground power unit may be removed after the first engine is started, since the operating generator and batteries can then handle ground power requirements.

The first step in engine starting is to clear the cylinders of any residual fuel or oil, by engaging the starter and turning until 15 propeller blades have been counted for a cold engine, and 6 blades for an engine that has been run within the previous two hours. The propeller should be watched during this operation and any tendency to hesitate or kick back should be noted and investigated.

At this point, the fuel boost pump should be placed in the ON position and the ignition switch turned ON. The ignition boost is energized and engine priming commenced with the amount of prime used dependent on engine and ground temperatures.

Prime intermittently, if engine is warm; continuously, if engine is cold. It is better to use too little prime than too much. Over-priming permits fuel/air mixture to exit from the exhaust system; then, after a short period of cranking with excessive fuel, the engine may fire and ignite the fuel/air mixture which has collected.



PROPELLER BLADE CHECK

After the engine fires, it should be brought up to at least 500 to 700 rpm on the primer alone, at which point the mixture control handle should be brought slowly out of idle cutoff position to auto-rich, reducing the prime application when a drop in rpm is noted.

In cold weather, engine operation immediately after starting is frequently rough, with backfiring and afterfiring. This is due principally to a lean carburetor idling mixture and to reduced vaporization of fuel. Turn on carburetor air preheat about one minute after starting. This will increase fuel/air ratio (in idling range) and will improve vaporization of fuel. After engine crankcase and cylinders are well warmed, engine operation will be satisfactory with cold carburetor air. Full cold carburetor air temperature should be used when engine operation is satisfactory.

OIL PRESSURE CHECK

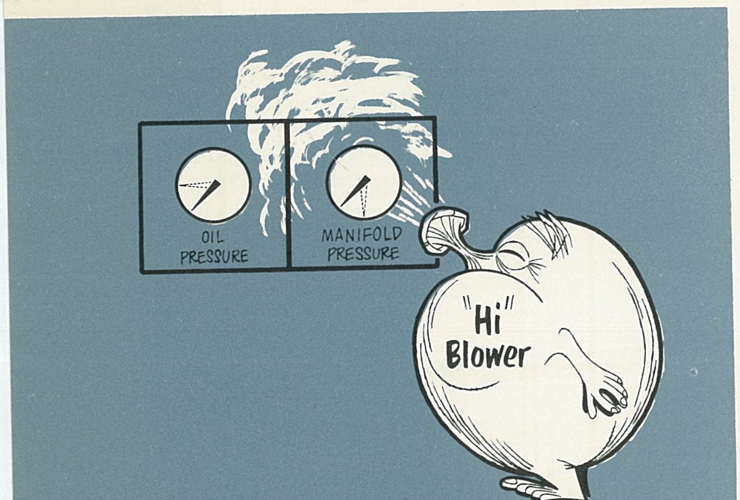
An all-engine prime switch (installed on some airplanes) actuates priming solenoids on each engine simultaneously, thus supplying the engines with additional fuel for a short period of time. The all-engine prime, or individual engine prime switch may be used for the following purposes:

1. In conjunction with manual leaning procedures, as specified by the engine manufacturer.

2. To provide a means of "shocktreating" lead-fouled spark plugs.

3. To make available a richer mixture in the event of carburetor malfunction at extreme altitudes.

As soon as engine is running, a check should be made of the engine oil pressure and, if it fails to rise, engine operation should be immediately discontinued. After oil pressure is observed, the engine should be stabilized at not over 1200 rpm with the throttle until engine warm-up is accomplished.



BLOWER POSITION CHECK

Engine failures have resulted from applying power to the engine too quickly after starting when the engine is cold. Care should be exercised not to exceed 1000 rpm until the oil temperature has reached 40°C. When oil temperature has warmed to 40°C, the propeller check procedure may be started, at the completion of which cylinder head temperatures will be satisfactory for completion of the ground check.

GROUND CHECKS

Note

Propeller ground checks and control will be discussed in a forthcoming issue.

At completion of the propeller check, throttles should be advanced to give field barometric pressure (2000 to 2150 rpm). At this point, check the propeller rpm and BMEP values on the BOTH magneto position. If these values are noted as being within limits for the power check, proceed to the normal magneto check procedure.

The blower position check is then made at the same manifold pressure setting, by moving the actuator switch to HIGH blower position and observing immediate rise of approximately one inch Hg MP and a drop in oil pressure, which is an indication that the blower shift clutch is operating.

The switch is then returned to LOW blower position (noting a drop in BMEP) and left in this position for the remainder of the ground run-up.

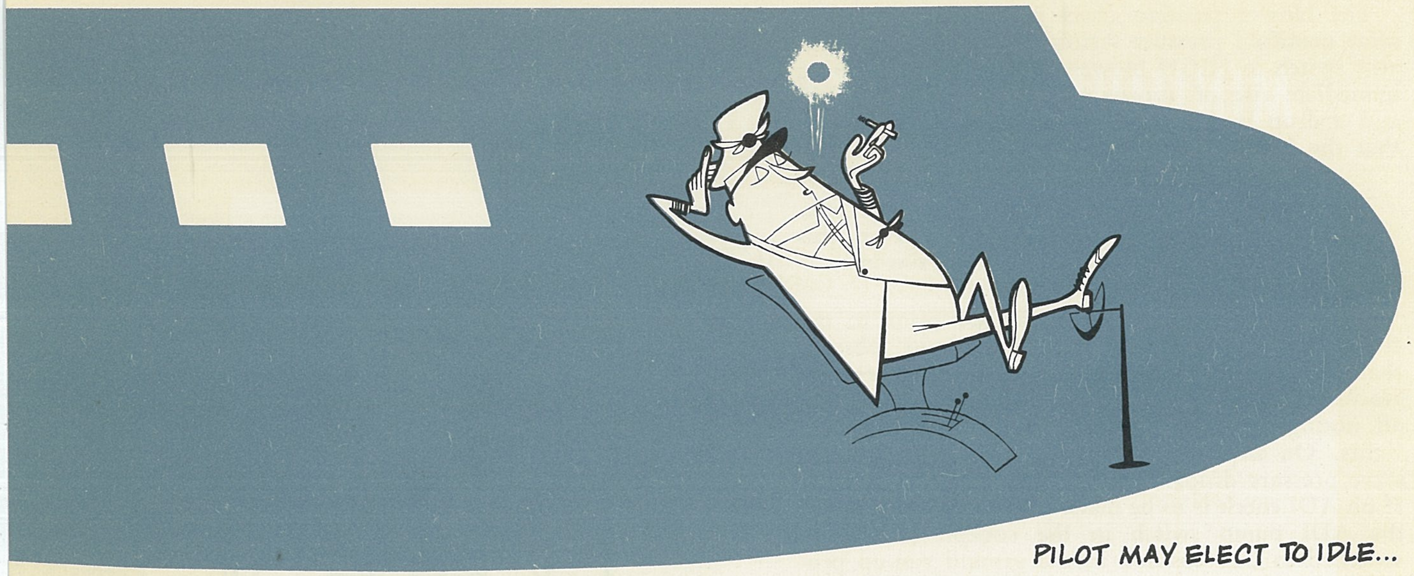
If an ADI system check is desired prior to the check performed during the takeoff run, observe that water indicator lights come on when pressure reaches 19±1 psi. At 40 inches Hg, turn water pump off, noting change in fuel flow, BMEP, and the water lights. On airplanes with water pressure gages, observe pressure drop, indicating that water is flowing. If no ADI check is to be made during ground run-up, the ADI pump switch in the cockpit should be switched to ON position in the ground run-up procedure sufficiently before takeoff to allow complete bleeding of the ADI system before application of takeoff power.

GROUND OPERATION

If there is an indication of plug fouling due to idle operation, the plugs can be cleared by slowly advancing the throttles until engine roughness is obtained. Reduce power slightly and, after a short interval, again increase power slowly until engine roughness is experienced. By successive "inching" of power, the plugs should be cleared at 2200 rpm and 37±2 inches manifold pressure. This procedure will clear plugs that have been fouled due to extended idle power operation.

It is undesirable to prolong high power ground operation because residual heat may damage ignition cables. Overheated ignition cables, engine mounts, and other important engine parts are not indicated on the cylinder head temperature gage; thus, care must be exercised so that engine parts do not become overheated. Cooling is considerably improved by facing the aircraft directly into the wind or as near to this position as possible during the ground run-up procedure.

Cylinder head temperatures normally read 150°C to 200°C after a run-up and before takeoff. The pilot may elect to idle for a short time to reduce temperatures to this range if for some reason the engine



PILOT MAY ELECT TO IDLE...

becomes overheated during run-up. In warm weather, cowl door openings should not be reduced for takeoff until after the aircraft has been cleared for takeoff and just before the throttles are opened to takeoff manifold pressure.

TAKEOFF

The use of full takeoff manifold pressure is recommended. Precautions should be taken, however, to avoid exceeding established takeoff manifold pressure limitations during the takeoff run. As the takeoff run is started, a manifold pressure increase may be observed, resulting from ram recovery, due to the forward speed of the aircraft. Throttles should be monitored as required to keep manifold pressures within limits.

During the takeoff, the ADI pressure gages (if installed) must be monitored. If pressure falls below minimum limits, the throttle on the affected engine must be reduced to the dry takeoff manifold pressure established for the engine, and the ADI turned off. The ADI system is normally turned off following the first power reduction.

CLIMB

Engine blowers should be shifted to HIGH when climb power can no longer be maintained in LOW blower with full throttle. The shift is accomplished in the manner outlined on another page.

The fuel flows should be monitored during climb to insure that each engine is getting the proper fuel flow. Detonation and resultant combustion chamber failures may occur if below minimum fuel flows are permitted.

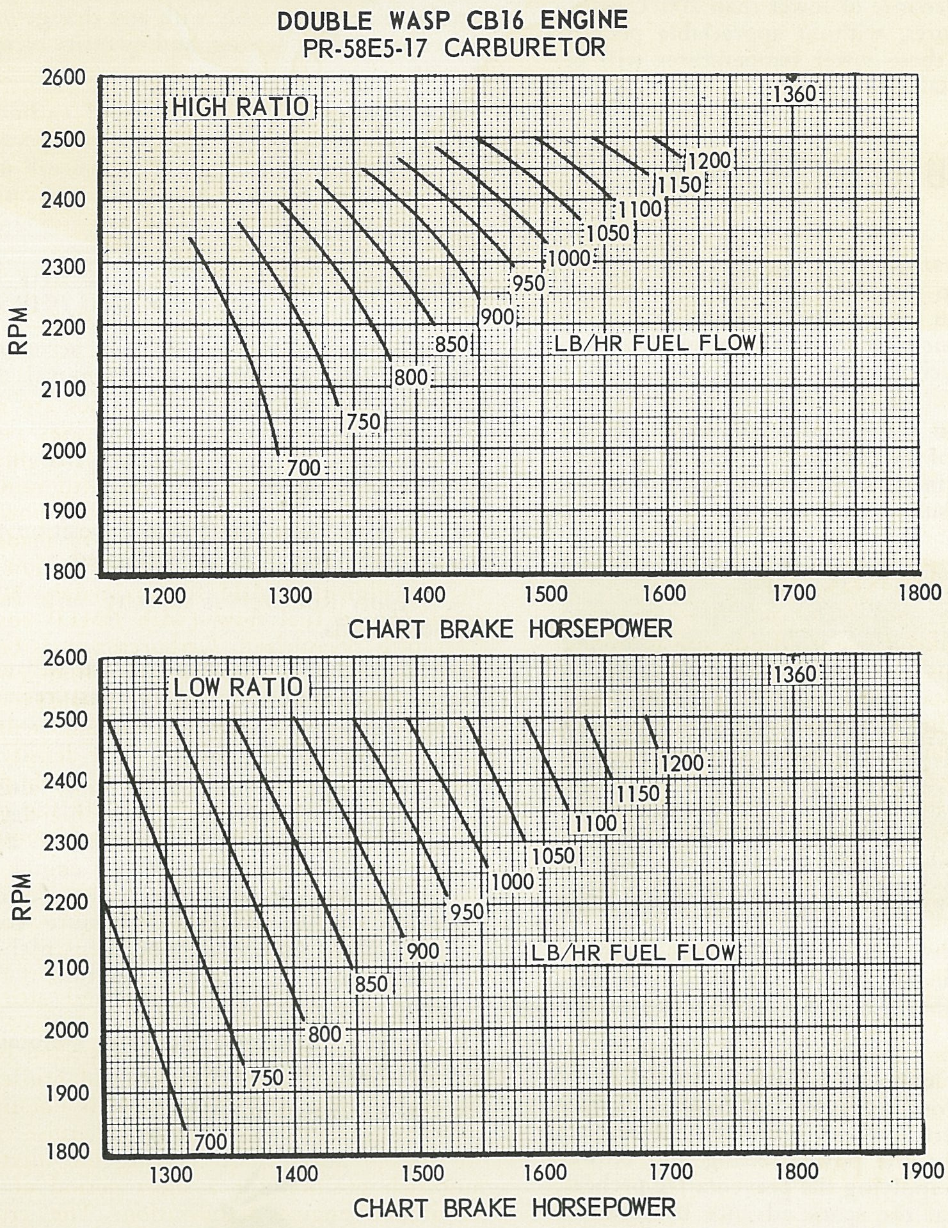
When minimum fuel flow values are not obtainable, and where operating conditions permit, it is recommended that the power on the offending engine be reduced in decrements until minimum fuel flow limits are met for the reduced power. In any case, a log book notation should be made to insure immediate corrective maintenance action in regard to the difficulty. Add approximately 50 lb/hr to right engine fuel flow (with BMEP equalized) if operating pressurized. Carburetor may be manually leaned as soon as feasible after climb power is set. Once fuel flows are set at climb BMEP, the carburetor automatic mixture control unit will automatically compensate for changes in air density so that, as throttles are opened to maintain climb power, fuel flows will remain at approximately the desired setting and will require only occasional monitoring.

CRUISE

On attaining cruise altitude and attitude, climb power is usually left on until the airplane accelerates to or slightly above the I.A.S. expected for the particular altitude, gross weight, and cruise power to be used. When desired airspeed is obtained, reduce manifold pressure and rpm to the cruise values given in the operating chart, leaving the mixture in the auto-rich position for a short period of time so as to insure engine stabilization. The cruise power settings are then established in accordance with the BMEP drop procedure, which will be discussed in another issue.

The high ram recovery characteristics of the air scoop make the engine manifold pressure particularly sensitive to airplane speed and attitude and is an item to bear in mind to achieve precise cruise mixture adjustment.

MINIMUM FUEL FLOW DURING CLIMB



The commonly used expression, "200°C desired cruise cylinder head temperature," has occasionally been misinterpreted. It is intended to mean that for increased durability of combustion chamber components during normal operation, it is desirable to keep head temperatures at or below 200°C; however, the mid-position of cowl door opening should never be exceeded in flight. Where cold outside air temperatures permit maintenance of lower than 200°C cylinder head temperatures, without appreciable penalty to cruise airspeed, these lower temperatures will be increasingly beneficial to the engine.

CARBURETOR ICE

Indications of carburetor icing generally appear as either a drop in manifold pressure, a change in fuel flow, a drop in torque pressure, and/or surging or misfiring. An increase in fuel flow usually indicates impact tube icing.

Ice that forms in the air passages within the air metering portion of the carburetor acts to substantially decrease or increase fuel flow, depending on its location, and results in a loss of power. Once this

ice has formed, it requires appreciable time, perhaps as much as 15 minutes, following the application of considerable preheat, to deice this portion of the carburetor.

In the event that high cruise spark advance is being used when icing conditions are anticipated, it will be necessary to ascertain which carburetor air temperature is allowed for the power setting and blower ratio in use. Before applying the preventative preheat, it is mandatory that the spark advance be returned to "takeoff and climb" position.

The basic intent of preventative heat is to raise the temperature level of the entire induction system so that extreme losses of power will not be encountered on entering icing conditions.

The application of preheat limits is, of course, dependent on so many variables that it is impossible to make any hard and fast rules except for the one of using preventative preheat. On entering the overcast or precipitation condition, carburetor air temperature must be monitored to maintain the heat at the proper level.

Use of carburetor heat for prevention of ice is self-explanatory and it remains only to caution that maintenance of a constant preheat value may require monitoring as the carburetor preheat temperature can fluctuate appreciably with any change of airspeed, power, cowl door setting, and quantity of moisture in the air.

Regarding the specific usage of carburetor heat, the CB series engine carburetor air temperature limits for continuous operation in 20° (takeoff and climb) spark advance position and cruise mixtures are:

LOW BLOWER	38°C
HIGH BLOWER	27°C at 1100 BHP or less 15°C at 1200 BHP or less

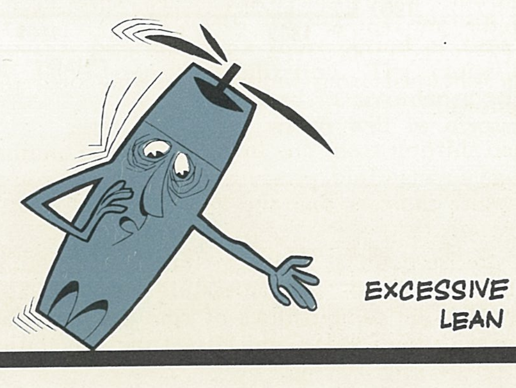
In cases where ice has already accumulated and carburetor heat is required for its removal, the following procedure applies:

1. Shift to 20° spark advance if high cruise advance is being used.
2. Shift to auto-rich mixture position and maintain until desired power is stabilized.
3. Apply full preheat capacity; hold full preheat for 30 seconds.
4. Slowly return preheat toward full cold to determine if fuel flow, manifold pressure, and BMEP are restored.

Note

Application of preheat at high altitudes will in itself cause an appreciable decrease in engine power output because of, a) the reduced air flow through the engine and, b) the leaning effect due to over-compensation of the automatic mixture control unit. When maximum continuous preheat is being used, the auto-rich mixture must be used.

5. Adjust carburetor heat to maintain proper carburetor air temperature.
6. Reset cruise mixture.



Experience indicates that the automatic mixture control unit tends to overcompensate for above standard temperatures; hence, when carburetor heat is applied, even though cruise mixture carburetor limits will not be exceeded, it is suggested that the mixture be first advanced to auto-rich position to avoid a period of excessive leaning which might result in engine instability. If established preheat level is below limits for cruise mixtures, reset cruise mixtures, after as much as five to ten minutes have been allowed for the AMC unit to stabilize.

Conversely, when the carburetor preheat is removed, automatic mixture control response is sluggish. It is suggested, therefore, that if preheat is removed while the engine is operating at cruise mixtures, the mixture controls first be placed in auto-rich to avoid excessive leaning which again can result in engine instability. When carburetor heat is removed, the heat control should be moved slowly toward the full cold position. As much as 5 to 10 minutes may be required for this operation. When this is accomplished, reset cruise mixtures. These cruise mixtures should be re-checked approximately 10 minutes after mixture control unit has assumed its stabilized position.

SHIFTING BLOWERS

Shifting blowers is electrically controlled by a switch on the pilots' pedestal. When shifting from LOW to HIGH, the throttle should be retarded to hold the selected manifold pressure.

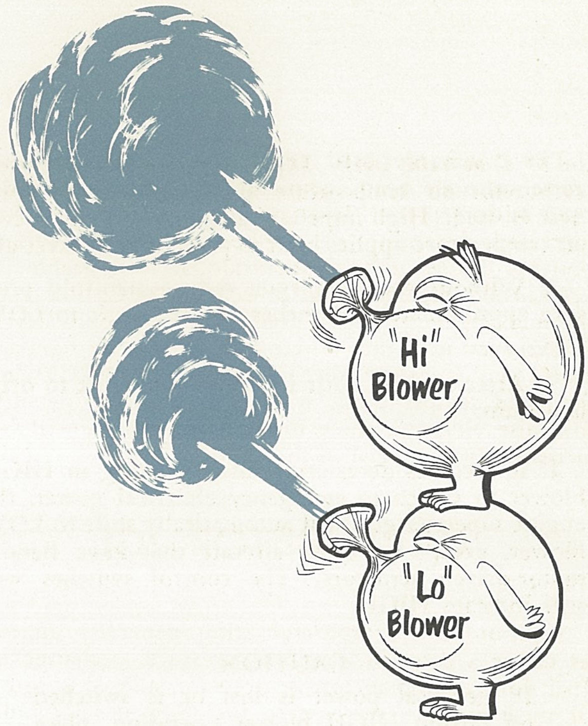
CB16 ENGINES

MAXIMUM CRUISE (LOW)		MAXIMUM CRUISE (HIGH)	
Mixture	Manual Lean	Mixture	Manual Lean
BHP	1240	BHP	1200
RPM	2300	RPM	2300
BMEP	155	BMEP	150
CHT	232°C	CHT	232°C
CAT	38°C	CAT	15°C

For a close approximation of best fuel economy, the low ratio should be used when the desired power can be obtained at the selected rpm. Low ratio should be used also when the desired power can be obtained using full throttle with an increase over the selected rpm, not to exceed the accepted maximum cruising engine speed. High blower should be used if the desired power requirements cannot be met with the low blower. High blower should NOT be used if carburetor air temperature exceeds 15°C at 1200 BHP (27°C at 1100 BHP). Specific power settings may be obtained from individual airline operating instructions.

When shifting from one impeller ratio to another, a change in manifold pressure and a brief drop in oil pressure indicate that the clutches have shifted.

The precise point at which to shift, during climb, must be determined from operating curves, taking into account the combinations of rpm and manifold pressure with both LOW and HIGH impeller ratios.



Following is a rule which will give reasonable accuracy, if the same combination of rpm and manifold pressure is used in both LOW and HIGH ratios.

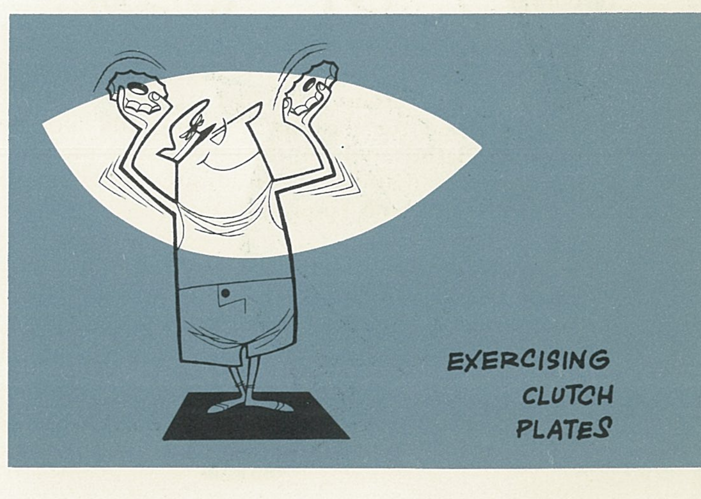
1. After passing LOW ratio critical altitude, continue climbing with full throttle until manifold pressure has fallen off 5.0 inches Hg.

2. Throttle, so as to reduce manifold pressure an additional 4.0 inches Hg.

3. Shift to HIGH; adjust throttle to the desired manifold pressure.

When operating continuously in either impeller ratio, exercise clutches every two hours in order to prevent accumulation of sludge. When flight is at an altitude that requires the use of HIGH ratio to maintain the engine power needed for satisfactory flight characteristics, this rule may be modified as follows:

1. Place mixture control in auto-rich, if carburetor air temperature is greater than 15°C at 1200 BHP



EXERCISING CLUTCH PLATES

or 27°C at 1100 BHP. LOW impeller ratio limit on carburetor air temperature applies only when preheat is used. High impeller ratio limit on carburetor air temperature applies both to preheat and direct air.

2. Without changing rpm, reduce manifold pressure approximately 25 inches Hg and shift to LOW ratio.

3. After positive shift is ascertained, shift to original ratio.

If it becomes necessary while operating in HIGH blower to switch to emergency electrical power, the engine superchargers will automatically shift to LOW blower, except on those aircraft that have Bendix motor-driven actuators. The control switches will still indicate HIGH.

CAUTION

> If electrical power is lost or is switched off during HIGH blower operation, place blower shift switches in LOW position. This will prevent excessive manifold pressure, should power be restored during a later phase of the flight.

Lead fouling of spark plugs during extended cruising operation can be cleared by advancing the mixture control to the auto-rich position for 30 to 60 seconds for every two hours of cruising operation. With the transport carburetor setting, an increase of 175 to 200 pounds per hour fuel flow can be obtained at cruise powers by moving the mixture from the manually adjusted cruise position to auto-rich. Hence, with this setting, it is possible to accomplish a spark plug deleading cycle, using the engine normal fuel distribution system, by simply moving the mixture to the auto-rich position. As previously mentioned, this deleading procedure can be made at the time of the two-hour engine supercharger exercises where, for other reasons, it is also desirable for mixtures to be in auto-rich. If high cruise spark advance position is being used when the deleading procedure is to be performed, spark advance should be returned to 20° before procedure is used.

RULE OF THUMB

It is desirable to check cruise mixture setting from time to time, especially if altitude, airspeed, or air temperature conditions change, to assure that the desired BMEP drop and therefore the desired combustion fuel/air ratio is being maintained during cruise under the altered operating condition.

A convenient and desirable point for shifting spark advance to takeoff and climb, if high cruise spark advance has been used, is immediately before the descent is started. Achieving the shift here assures that a positive indication of shift will be shown on the BMEP gage, whereas, if auto-rich mixtures are used in descent, the shift indication in descent may not be so apparent. It is also convenient to shift at this time to take advantage of the fact that the flight crew duties are lesser than later on, during descent. At any rate, the return to takeoff and climb spark advance must be made before the final approach, and a drop in BMEP should be observed to ascertain that shift has been accomplished.

DESCENT

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The engine supercharger should be shifted to LOW at any convenient altitude where power requirements may be met in LOW blower. The altitude for shifting the blower is not critical. It is unnecessary to retard throttles when shifting from HIGH to LOW except for considerations of passenger comfort.

If the descent is prolonged, the mixture may be left in cruise; however, engine roughness or backfire may be encountered in which case mixture should be richened sufficiently to avoid this difficulty. Cylinder head temperatures should be maintained at the cruising level as nearly as possible. If descent is made through turbulent air, the pilot may wish to select a lower value of cruising power and rpm. To avoid undesirably high inertia loads on master rod bearings, it is recommended that when using reduced powers, a rule-of-thumb minimum manifold pressure limitation of 1 inch Hg per 100 rpm be used; i.e., at 2200 rpm, the manifold pressure would be reduced to a minimum of 22 inches Hg. At high rpm and low manifold pressure, resulting unbalance of combustion gas loads and inertia loads can result in master rod bearing distress and eventual bearing failure.

The approach phase of the operation is fairly straightforward and consists of control positioning in the cockpit in preparation for the landing which is anticipated within 5 to 10 minutes. Among other items, it is very important that the spark advance be in the takeoff and climb position, the engine superchargers in LOW, and mixture in auto-rich.

LANDING

At high gross weights, it is required, and always desirable, that the ADI system be operating, in the event of a pull-up and go-around. If the ADI switches are turned on too early in the descent, considerable ADI fluid will be consumed and the supply may become exhausted during the approach operation. However, if the ADI system is to be turned on for the landing, this should be accomplished sufficiently in advance of the actual landing (2 to 3 minutes) to enable the system to be adequately bled.

Propeller reversing is usually employed immediately after the landing touchdown. When the airplane has forward motion, such as during the after-landing roll, engine cooling is less critical and cowl doors may be left in the last adjusted position prior to touchdown. The recommended procedure for use of cowl doors during propeller reversal after landing is:

1. In landing pattern, adjust cowl doors to a setting sufficient to provide desired cylinder head temperatures during approach and landing, but not beyond the mid-position. The doors should remain in this position throughout the propeller reversing operation.

2. For optimum braking efficiency, following touchdown, initiate wing flap retraction and, as the airplane weight settles on the landing gear, pull the throttles aft into the reverse thrust range for aerodynamic braking.

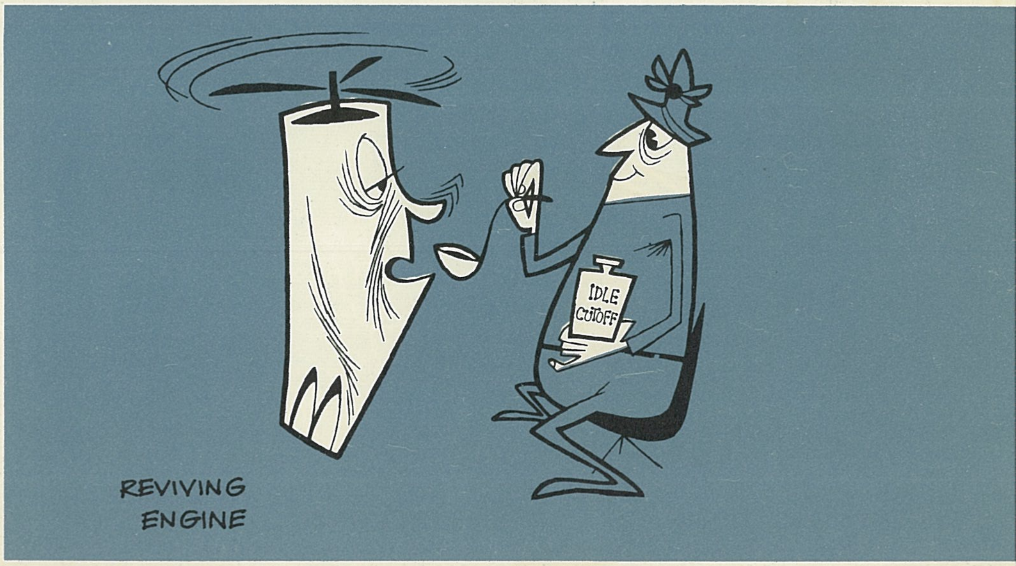
3. When the airplane has lost nearly all of its forward motion, move the throttles to the normal power-off position and apply brakes lightly. Open cowl doors fully.

The idle mixture adjustment of the carburetor becomes very important during propeller reversing and unreversing. An improper mixture setting will cause the engine to hesitate, backfire, or lose rpm and stall. An engine that is rich in idle at sea level will become more critically rich at altitude airports and thus be more likely to stall during propeller reversing procedure. If these engine operating symptoms are exhibited during propeller reversing, the idle setting should be adjusted. An engine dying from a rich mixture can often be recovered by placing the mixture control momentarily in idle cutoff position until rpm responds sufficiently to assure satisfactory operation.

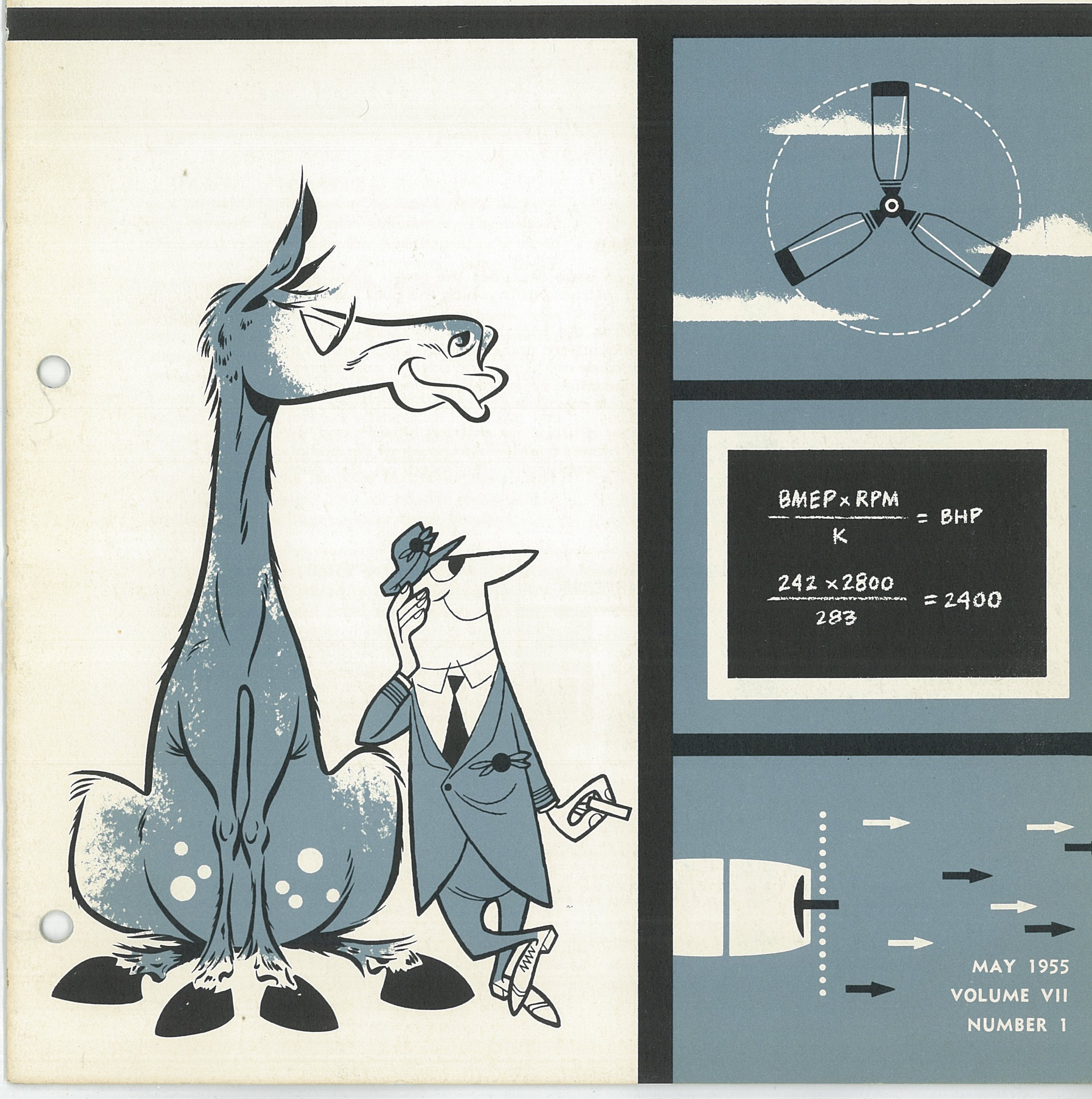
SHUTDOWN

If for some reason cylinder head temperatures are above 200°C, at the time it is desired to shut down the engine, the engine should be idled at 1000 rpm long enough to reduce cylinder head temperatures to this value, to avoid excessive overheating when engines are stopped. 14 62

Shutdown is accomplished by placing mixture control in idle cutoff position, not by cutting switches only. Switches should not be cut until propellers have stopped turning. It is not necessary and is even undesirable to advance throttles to full open position after cutting mixture and switches. Such action can result in undesirable effects such as condensation of moisture on spark plugs due to quick chilling action on combustion chamber compounds. Cowl doors should be left open long enough to permit residual heat to escape from the engine. The top half of the engine actually increases in temperature during the first five minutes of shutdown. It is important to get this heat out of the nacelle before cowl flaps are closed for purposes of parking the airplane. This practice is desirable even in very cold weather when it is desired to retain heat in the engine during a station stop on the line. After a minimum of 15 minutes, the cowl doors may be closed completely, if desired.



Convair TRAVELER



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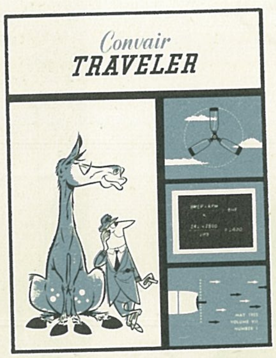
FOREWORD

The March issue describes the power plant controls and instruments by which the pilot regulates performance of the engines. This issue, which supplements the March issue, discusses takeoff power calculations and the BMEP drop method of setting cruise mixtures. Included is information on the operation of propellers, and in-flight reversing tests conducted by United Air Lines.

The proper altitude for shifting blowers and the effect of blower operation on power at various altitudes is graphically illustrated on the back cover.



ON THE COVER

Formulas, figures, and more figures have Willis Goldsmith slightly confused. But then, he's an artist, not a pilot. If you haven't guessed it, he's trying to illustrate BMEP drop, takeoff horsepower, propeller feathering, reversing. The only thing that confuses us is the horse. What is it doing in the picture?

Chief Engineer
F. W. Fink

Chief of Service
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CONVAIR
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(SAN DIEGO)

SETTING CRUISE MIXTURE

The BMEP drop method of setting cruise mixture is a procedure based upon the fundamental relationship between fuel-air ratio and power. The method eliminates reliance upon the quantitative accuracy of torquemeter systems and flowmeters, using BMEP gages only for relative measurement.

Use of the BMEP drop method will insure that both engines are operating at the same mixture strength. With both engines set to a single manifold pressure, BMEP gages will vary due to the horsepower absorbed by the cabin compressor of the right engine; however, mixture strength and uniform fuel consumption should result in economies from fuel savings and improved engine condition. In addition, this method is the simplest to use in the cockpit, utilizing BMEP gages only for relative measurement, and fuel flow readings only for check purposes.

By increasing the manifold pressure of the right engine to equalize BMEP readings, thus balancing the horsepower delivered to the propellers, performance can be improved equal to that with compressor disconnected. The balanced BMEP procedure, though not as simple to establish as the balanced manifold pressure procedure, is preferred by some operators.

Note

Cruising airspeeds at specific powers should be based upon the following formula:

$$\frac{2 \times \text{average BMEP} \times \text{rpm}}{K(283)} = \text{Total propeller shaft HP}$$

Basically, both procedures provide for establishing the desired fuel-air ratio with as many factors as possible held constant. Only fuel flow is varied, and resulting changes of power follow closely the fundamental relationship between fuel-air ratio and power (see figure 1).

Thus, the BMEP drop method is a locked-throttle procedure for setting cruise mixture with reference to Best Power. Best Power fuel-air ratios define the mixture range at which the engine develops maximum power at a fixed throttle setting. As the mixture is leaned or enriched from Best Power, the power will fall off at a very consistent rate (see figure 1) and this power loss can be measured directly with the BMEP gage. Knowing the relationship of mixture strength to power, the desired cruise mixture can be obtained with a certain drop in torque pressure, which can be indicated as BMEP, from the Best Power peak. This procedure is outlined step by step as follows:

1. After reaching cruise altitude and leveling off, establish the desired cruise values of rpm and manifold pressure (corrected for CAT) with the mixture control in auto-rich. Allow flying conditions (IAS, CHT, CAT, etc) to stabilize for about five minutes with the airplane trimmed for cruise flight. Set the mixture for the left engine first.

2. Note the BMEP obtained in auto-rich. Auto-rich is usually at or slightly richer than Best Power at cruise BHP.

3. Manually lean the mixture from auto-rich. The peak BMEP will occur at auto-rich or as the mixture control is leaned slightly from auto-rich. This is Best Power.

4. Fix in mind the peak BMEP observed in steps 2 and 3; then continue leaning the mixture until a fixed BMEP drop is observed below the maximum reading.

The exact BMEP drop varies depending on the engine and operating conditions. P&W will advise what BMEP drops are approved for a specific operation. The usual minimum fuel-air ratio desired for cruise is a Rich Best Economy setting of 0.0625 (12 BMEP drop). Because of the increased power available with richer mixture the difference in brake specific fuel consumption between operation in this range and operation at Best Economy of 0.060 (18 BMEP drop) is very slight; hence, there is no appreciable sacrifice of economy in operating at the richer settings. In some cases, rich fuel-air ratios up to 0.070 (2 BMEP drop) are preferable.

5. After setting mixture of left engine, recheck manifold pressure and BMEP readings.

a. If a balanced manifold pressure is preferred, adjust manifold pressure of right engine to that of left, and set mixture of right engine in accordance with steps 2, 3, and 4.

b. If a balanced BMEP is preferred, increase manifold pressure of right engine to a value (approximately 1″ Hg at cruising BHP) sufficient to provide the desired BMEP reading. Lean the mixture until the fixed BMEP drop is observed, below the maximum reading, in accordance with steps 2, 3, and 4.

When foregoing procedure is attempted with carburetors incorporating automatic settings (–4 settings), it may be necessary to use prime to establish Best Power.

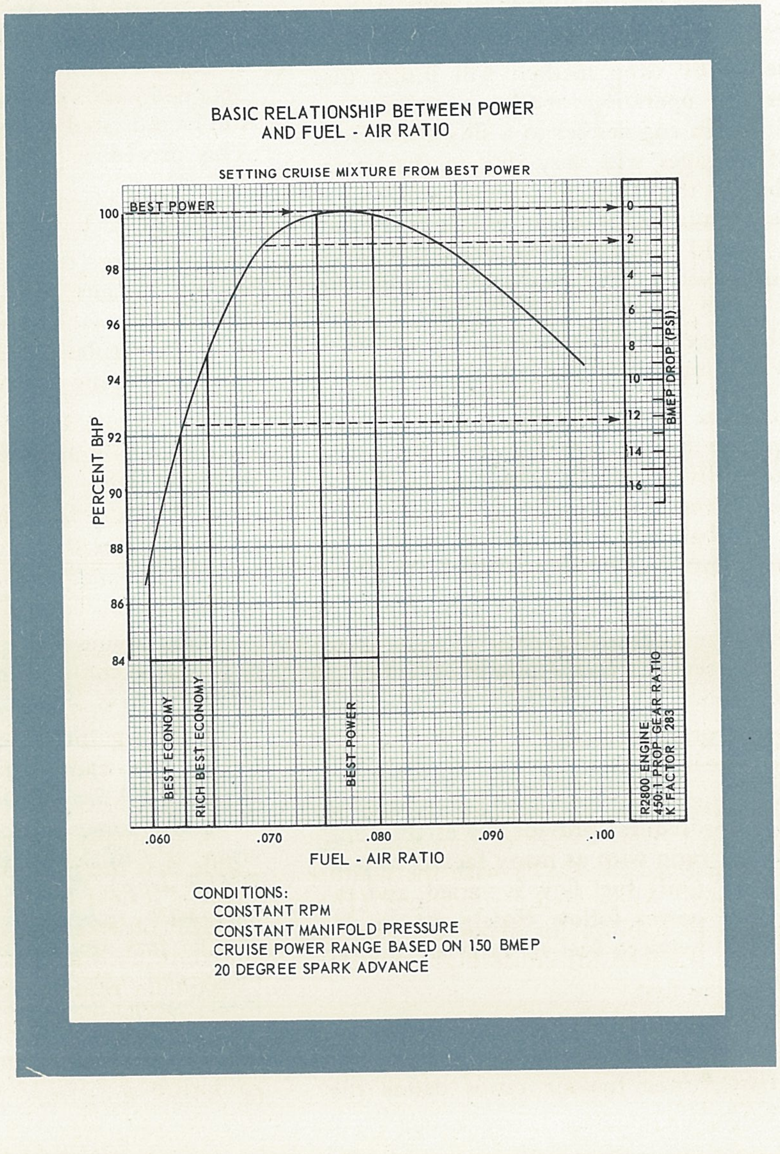
On a normal engine with a properly metering carburetor, auto-rich should be at, or close to, Best Power mixture. When prime is applied with the mixture control in auto-rich, the following relationships apply as shown in figure 2.

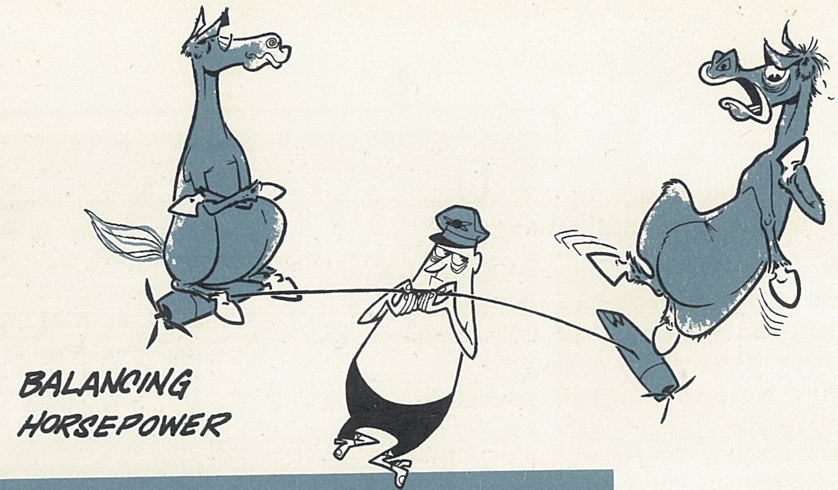
a. If the BMEP drops, auto-rich is at or richer than Best Power. If it is richer than Best Power, the BMEP will rise as the mixture is manually leaned from auto-rich (figure 2, case 1).

b. If the BMEP does not change, either auto-rich is near the lean end of the Best Power mixture range (figure 2, case 2) or the primer is inoperative. To check for possible primer malfunction, manually lean the mixture until a perceptible drop in BMEP occurs; then apply prime. If the primer is working, there will be an immediate rise in BMEP (figure 2, case 4).

c. If the BMEP rises, or rises and then falls, auto-rich is leaner than Best Power (figure 2, case 3 or 4).

FIGURE 1





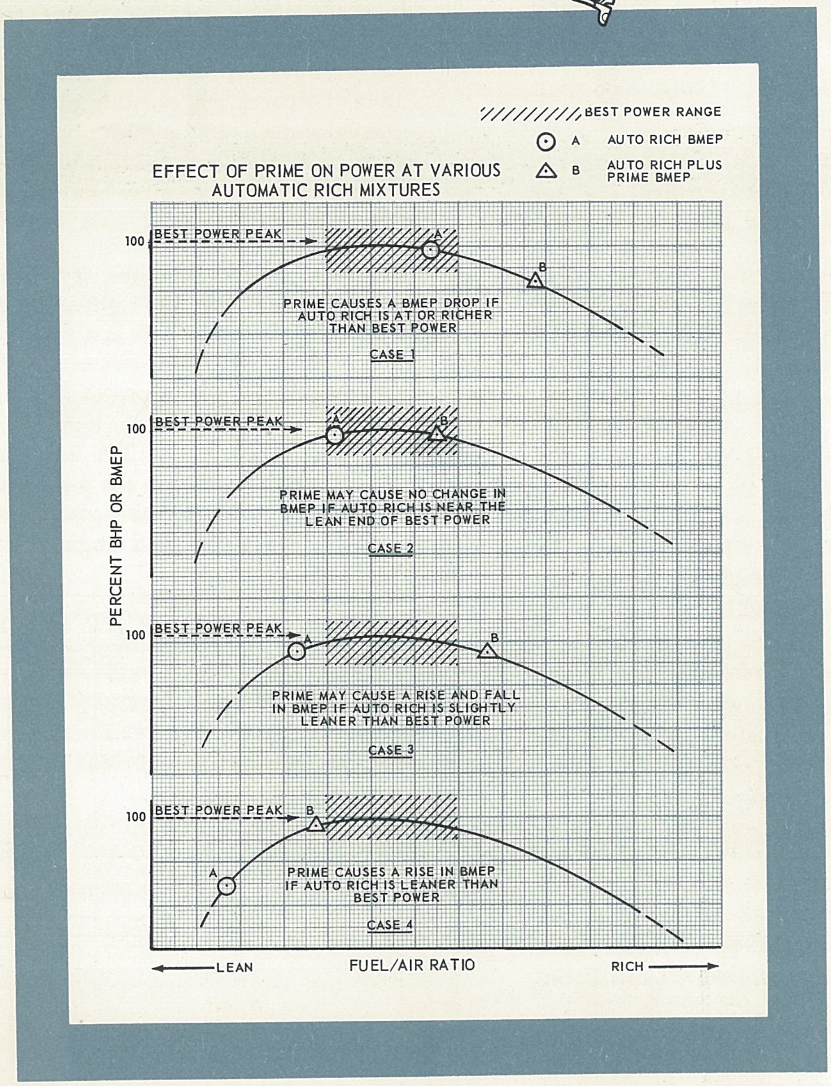


FIGURE 2

The following procedure may be used to determine the Best Power peak.

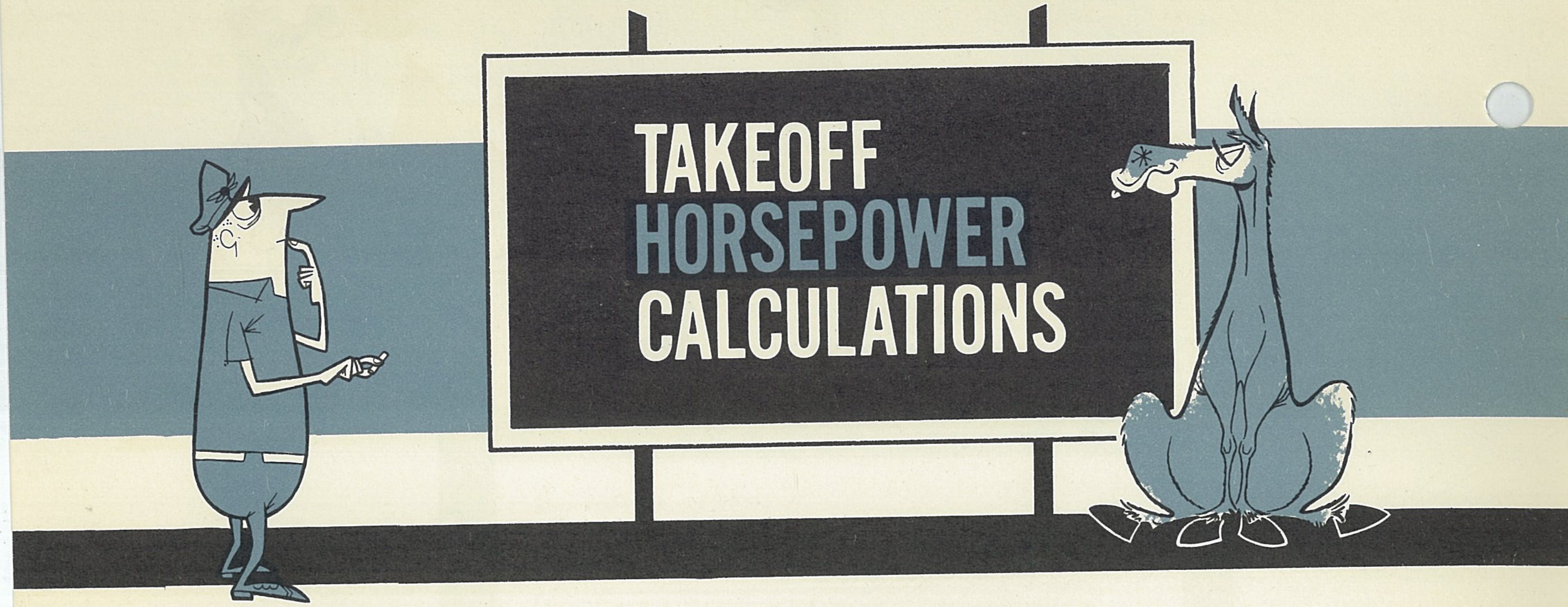
1. After reaching cruise altitude and leveling off, establish the desired cruise values of rpm and manifold pressure (corrected for CAT) with the mixture control in auto-rich. Allow flying conditions (IAS, CHT, CAT, etc) to stabilize for about five minutes with the airplane trimmed for cruise flight. Set mixture for left engine first.

2. Note BMEP obtained in auto-rich. Auto-rich is usually at, or close to, Best Power at cruise BHP.

3. Engage primer and watch BMEP gage for rise, drop, or steady indication. Note maximum BMEP reading.

4. Manually lean mixture from auto-rich. It is possible that the peak BMEP will occur as mixture control is leaned from auto-rich. Fix in mind the peak BMEP observed in steps 2, 3, and 4; then lean the mixture until a fixed BMEP drop is observed below maximum reading observed.

5. After setting mixture of left engine, recheck manifold pressure and BMEP readings.



TAKEOFF HORSEPOWER CALCULATIONS

The R-2800 engine develops the specified takeoff horsepower at 2800 rpm and the specified manifold pressure only when carburetor air inlet temperature and humidity are at standard values (59°F, or 15°C, and 80% relative humidity).

If carburetor air inlet temperature is above standard, delivered horsepower will be less than normal; if inlet temperature is below standard, delivered horsepower will be greater than normal. If humidity is above 80%, decreasing the weight of air per unit volume intake, a piston engine will experience a loss of horsepower (BMEP), due to the reduction of weight airflow available for combustion under constant rpm. As the carburetor does not compensate fuel flow for humidity change, the fuel-air ratio will rise, causing enrichment and loss of power. The reverse is true for below standard humidity.

Generally speaking, it would then be necessary to correct the computed horsepower of the engine by adding or subtracting outside air temperature and humidity corrections. With the torquemeter gage, humidity and O.A.T. are not required for calculating BHP.

Actual horsepower is determined by a combination of torquemeter indication and rpm. The BMEP gage, or torquemeter, indicates the amount of torque actually delivered to the propeller shaft. These torque forces are not influenced by temperature or humidity.

The amount of horsepower delivered to the propeller shaft during the takeoff roll may be calculated by combining BMEP and rpm readings with the BMEP constant (K), a figure established by the engine manufacturer. The result of $\frac{\text{BMEP} \times \text{rpm}}{\text{K}} = \text{BHP}$.

The constant (K) for the R-2800 engine is 283.

When setting takeoff power, it will be noted that the torque reading of the right engine is less than that of the left engine. This is a result of the power absorbed by the cabin compressor, which is driven by the right engine. The horsepower indicated by BMEP and rpm for the right engine, however, is the actual propeller shaft horsepower. The amount of compressor load HP can be added to the propeller shaft horsepower in order to know the power which would be produced by the right-hand engine, were the compressor disconnected.

COMPRESSOR HP AT T.O. RPM	
Full Cold	75 HP
Unload or Hot	40 HP

To calculate actual engine horsepower:

1. Set takeoff horsepower.
2. Record readings of rpm and BMEP gages.
3. Apply K factor as follows: $\frac{\text{BMEP} \times \text{RPM}}{\text{K}} = \text{BHP}$

ENGINE	RPM	MAP	BMEP
Left	2800	59.5	242
Right	2800	59.5	234

LH Engine: $\frac{242 \times 2800}{283} = 2400$

RH Engine: $\frac{234 \times 2800}{283} = 2315$

Since the right-hand engine has a lower resultant propeller shaft horsepower, due to the compressor load, an automatic compressor disconnect is incorporated in the airplane in the event a failure occurs to the left-hand engine and the propeller is feathered. This feature assures that maximum power and airplane performance will be obtained.

340 PROPELLER MANAGEMENT

The minimum effective takeoff field lengths and the maximum takeoff weights permitted are based on the use of the autofeathering system, should engine failure occur during takeoff. If the airplane is dispatched with the autofeathering system inoperative, the airplane must be operated in accordance with Appendix C of the 340 Flight Manual.

Both generators must be operative since propeller feathering is dependent upon two-generator operation. BMEP gages should be cross-checked frequently against manifold pressure and rpm so as to determine if an abnormal indication of torque pressure is present, a condition that requires correction before takeoff.

Two test switches have been provided to insure proper operation of the autofeather system. Each has two positions—NORMAL and TEST—and is so connected that when it is held in the TEST position, the throttle switch is bypassed and the test circuit completed without the throttle being in T.O. power position. Reducing power below 80 BMEP by retarding the throttle with the switch in TEST will start autofeathering operation, which can be discontinued by pulling out the respective feather button.

A time delay of approximately two seconds has been incorporated to eliminate the possibility of the propeller feathering during any temporary interruption in engine power. With one propeller feathered, the circuit is rendered inoperative and the second propeller will not feather automatically unless the autofeather arming switch is turned off and then on again.

Whenever the left-hand propeller is feathered, either automatically or manually during takeoff or in flight, a solenoid-actuated compressor disconnect withdraws the cabin compressor spline from the drive pad on the right-hand engine, thus removing the compressor load and making more power available to the right-hand propeller.

CAUTION

During ground feathering checks of the left-hand propeller, throttle should not exceed 45 inches MAP (approximately 2/3 open) so that inadvertent disengagement of the cabin compressor does not occur.

Two push-pull switches, located on the overhead switch panel are provided to control manual propeller feathering. The button is pushed in to feather—pulled out to unfeather, the middle position being the normal position. If the feather button does not automatically pop out when feathering is completed, the feather button must be pulled out manually to prevent overheating of the feather motor. The red light in the feather button will remain on until the propeller is feathered and the button pops out. When unfeathering in flight, the feather button should be held out only until propeller rotation begins. This will normally be in one to two seconds. If the feather button is held out continuously, the propeller will be positioned near the low-pitch stop, which will overspeed the engine at high airspeeds.

AUTOFEATHER CHECK

Following is the minimum check required of the autofeathering system prior to each flight.

1. With the engine either operative or inoperative and the right-hand throttle 1/2 open, place master autofeather switch in the ON position. The green arming indicator light and red feather button lights for both propellers should glow.

Note

If check is made with engine inoperative, use auxiliary power unit.

2. Hold right-hand autofeather test switch in the TEST position.

3. Observe feathering action of the propeller. When feathering starts, the right-hand engine feather button will pull in and the red light will stay on until the propeller is feathered. The red light in the left button will go out at the start of the feathering cycle.

Note

On –61 series airplanes, the red light will come on when propeller starts to feather.

4. Release test switch and pull feathering button to the half-out normal position to stop feathering action before propeller fully feathers. The green light, which indicates an "armed" autofeather system, will go out only after a feathering cycle is completed.

Note

With engine inoperative, pulling the feathering button to normal before propeller fully feathers eliminates the possibility of excess oil draining to the engine sump with possible hydraulicking during subsequent engine starting.

5. Turn autofeather switch OFF, then ON, to re-arm system.

6. Ascertain that autofeather green indicator light and both manual feather button red lights are ON.

7. Repeat steps for other engine.

Notes

1. Leaving autofeather switch ON after the test is completed will leave the system unarmed and inoperative. The switch must be turned OFF after each test. It is turned on again just prior to take-off.

2. On application of power for take-off, check that green lights are on. Red lights should go out. If they do not, it indicates a malfunctioning torque pressure switch, and propeller will feather when throttle is further advanced.

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PROPELLER SPEED CONTROL

Propeller speed is controlled by two switches on the control pedestal. The switches have three positions: INC, DEC, and OFF. The length of time that a switch is held in either INC or DEC regulates the amount of RPM variation. A light adjacent to each switch illuminates to signify that the governor has reached either the high or low pitch limits.

With engine operating, check propeller control by setting throttles to 1500 rpm, and moving the control to DEC rpm until limit lights come on. (Minimum rpm when lights come on should be approximately 1200). Then set control back to the high rpm limit.

ASCERTAIN THAT NOTHING IS AHEAD...

CAUTION

During cold weather operation, propeller should be cycled several times to insure hot oil in the propeller dome.

PROPELLER REVERSAL CHECK

Propeller reverse pitch tests should be made before the first flight of the day. Reverse pitch will normally be used after each flight during the landing roll and therefore need not be checked before each flight.

Before making reverse pitch test, exercise propellers several times in order to circulate warm engine oil through the propeller system. Ascertain that nothing is ahead of the airplane that may be damaged by propeller blast. Perform check on one propeller at a time with the opposite engine operating at approximately 1500 rpm. This procedure assures generator power on the main bus and precludes excessive drain on battery power.

1. Pull throttle back slowly through throttle closed detent into the reverse operating range. Watch d-c loadmeter increase as the feathering pump starts, and watch for rpm increase as the propeller passes through flat pitch. Watch for d-c loadmeter decrease when feathering pump stops.

CAUTION

Observe cylinder head temperatures closely when operating with propellers in reverse pitch. Limit use of high power settings with propellers in reverse pitch to short intervals. Conduct reverse pitch tests within a range not to exceed 50% of full throttle.

2. Return throttle to normal operating range. Watch for d-c loadmeter indication when feathering pump starts and stops.

CAUTION

Watch for a surge of approximately 200 to 300 rpm when returning throttle to normal operating range. This surge will occur as the blades pass through flat pitch, and will serve to indicate that propeller has returned to forward thrust operation.

3. Repeat procedure on other propeller.

A positive check to ascertain forward propeller pitch following reversal is to momentarily depress each feathering button. If rpm decreases, propeller is in forward pitch; if rpm increases, propeller is still in reverse pitch.

Propeller reversing after the landing touchdown is discussed in the March 1955 issue of the Traveler.

PROPELLER DE-ICING

The propeller de-icing system incorporates electrical heating elements installed in the leading edge of each blade. The de-icing switch has three positions: HIGH (fast), OFF, and LOW (slow). A de-icing timer, controlled by the switch, controls application of power in cycles to heat each propeller alternately for a given time. The HIGH rate regulates power application to left or right propeller blade heaters in a cycle as follows:

BENDIX TIMER

HIGH: Right-hand ON for 20 seconds; Both OFF for 20 seconds; Left-hand ON for 20 seconds; Both OFF for 20 seconds.

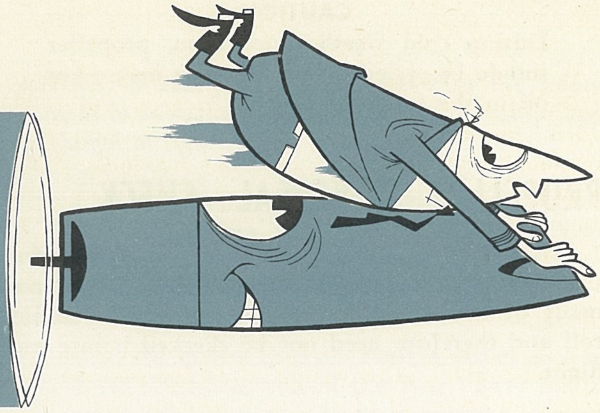
LOW: Right-hand ON for 40 seconds; Left-hand ON for 40 seconds; Both OFF for 80 seconds.

HAMILTON STANDARD TIMER

HIGH: Left-hand ON for 20 seconds; Right-hand ON for 20 seconds; Both OFF for 40 seconds.

LOW: Left-hand ON for 60 seconds; right-hand ON for 60 seconds; both OFF for 120 seconds.

IN FLIGHT REVERSING TESTS



United Air Lines recently completed flight tests on the Convair-Liner 340 in order to explore the flight characteristics and performance with asymmetrical thrust distribution involving windmilling and reversing propellers. The results of these tests are being presented to provide operators with basic information as to what might be expected should a propeller reversal, however improbable, be experienced during normal airline operation.

Reversing in flight was accomplished by pulling the throttle through "closed throttle" position into the reverse power range after first arming the reverse system by pulling out the Tee handles. No attempt was made to modify the electrical circuitry such as to permit changing the propeller blade pitch from forward to reversed pitch with throttle open; thus, full simulation of in-flight unwanted reversing was not evaluated.

The test was made in the following configuration:

Fuel on board	3700 lb
Ballast	680 lb
Takeoff Gross Weight	36,500 lb
Average weight during test	35,500 lb
Crew members	2
Observers	2
Gear and wing flaps	UP

After airspeed was stabilized at the desired altitude, METO power was set up on one of the engines with the throttle of the other engine pulled towards closed position. Reversing was accomplished by pulling the throttle of the idled engine firmly through idle position to reverse without causing the engine to severely overspeed as the propeller went through zero pitch. Slowly, but firmly, power was applied to this engine until full throttle was obtained while flight controls were applied as required to maintain constant heading and desired airspeed. After cursory check on control forces, the airplane was trimmed for "hands off" flight. Data were observed and recorded simultaneously on the following items:

Maximum rpm reached while reversing
Stabilized rpm, MAP, and BMEP at full throttle
Altitude loss
Amount of trim required.

Unreversing was accomplished in a normal manner by pushing the throttle forward firmly through idle position into the forward open throttle position. The feather button was not used in reversing or unreversing. It was used only in the event the engine stalled upon closing the throttle after the propeller had operated in full power reverse. It was necessary to feather the propeller to prevent windmilling backward and subsequent damage to the engine.

The most severe asymmetrical thrust distribution involved the use of METO power on one engine and full power reverse on the opposite engine.

Under this condition, all controls were found to be adequate from 160 knots down to 110 knots IAS. At 110 knots, full rudder control and considerable aileron were required to maintain a constant heading. To trim out the airplane, 9° (full) rudder trim and 7° aileron were required. Airspeeds in excess of 160 knots were not evaluated.

High noise level was experienced only as the propeller went into reverse. This was a transient condition similar to an overspeeding propeller.

Highest rpm reached during the transient period, as the propeller went through flat pitch into reverse, was 2550. This was associated with high airspeed. The high rpm noted is a transitory state which did not last more than 1 to 2 seconds, after which it fell off rapidly to a stabilized value with only mild oscillation.

At full reversed power, the engine stabilized more or less at a maximum rpm between 1300 and 1700, dependent upon airspeed. RPM was inversely proportionate to the true airspeed. The maximum MAP recorded was 28 and 36 inches hg respectively. The computed horsepower was in the range of 600 to 1110 BHP. Vibrations encountered while at full reverse power were moderate and the instrument panel was readable with no difficulty.

At an average gross weight of 35,500 pounds, and under conditions of most severe asymmetrical thrust distribution, the rates of descent were found to be quite high. In fact, this precluded the possibility of staying in the test condition for a protracted period to reach stabilization. The average rates of descent versus airspeed were recorded as follows:

TIAS (KNOTS)	RATE OF DESCENT (FT/MIN)
174	—2470
152	—1950
131	—1780
121	—618

As noted, rates of descent are sensitive to airspeed, the rates of descent decreasing considerably, though still negative, as airspeed is reduced. It should be remembered that one of the engines is still producing full reverse power in the order of 800 to 1000 BHP in the negative thrust direction, not withstanding the fact that the other engine is producing near METO power of approximately 1700 BHP. A steep angle of dive and resulting high rate of descent was necessary to maintain the desired true airspeed in this configuration.

Closing the throttle of the engine on which the propeller was operating in negative pitch, produced very significant changes in severity of the amount of controls required to hold a heading and rates of descent. The amount of controls or trim required approached that which is required for a normal windmilling propeller condition. Closing the throttle to the point of 1000 rpm or less caused the engine to stall out and the propeller to start windmilling backwards. This is indicated by a zero indication on the tachometer while the propeller was windmilling backwards. Noise and vibration levels in general subsided to a great degree.

As a comparison, tests were conducted at the same airspeed and altitude and very nearly the same gross weight but with the propeller windmilling at the low-pitch stop (+30°) and closed throttle. Controls and trim required were much less than that required under similar conditions when full reversed power was employed, Positive rates of climb were available at 152 knots true airspeed, or below. At a high airspeed of 173 knots, negative rate-of-climb (descent) was experienced. This is not unexpected, however, as the airplane was operated beyond the speed for best rate of climb.

On all conditions attempted, no violent swinging or yawing of the airplane was experienced during the transient or stabilized conditions.

From these tests and operational experience to date, it cannot be accurately predicted as to what effects would be encountered should a propeller suddenly go into reverse pitch at cruising speeds and power settings. Controllability of the aircraft, however, is expected to be most critical at low airspeeds and high powers.

Confusion is apt to result during an unexpected reversal. The propeller noise resulting from the overspeed as the blade angle enters the flat pitch range is unmistakable. The higher the airspeed, the higher the noise level. The deceleration of the airplane and possible yaw, buffeting, or bucking effect would be pronounced at higher airspeeds.

Confusion in the cockpit could result if the reversing is unexpected. This confusion unquestionably will make it difficult to execute any complex procedure. For this reason, if a suspected reversing occurs at any but the most critical flight regimes (and perhaps even then), the following UAL recommended procedure may be used.

1. Close all throttles.

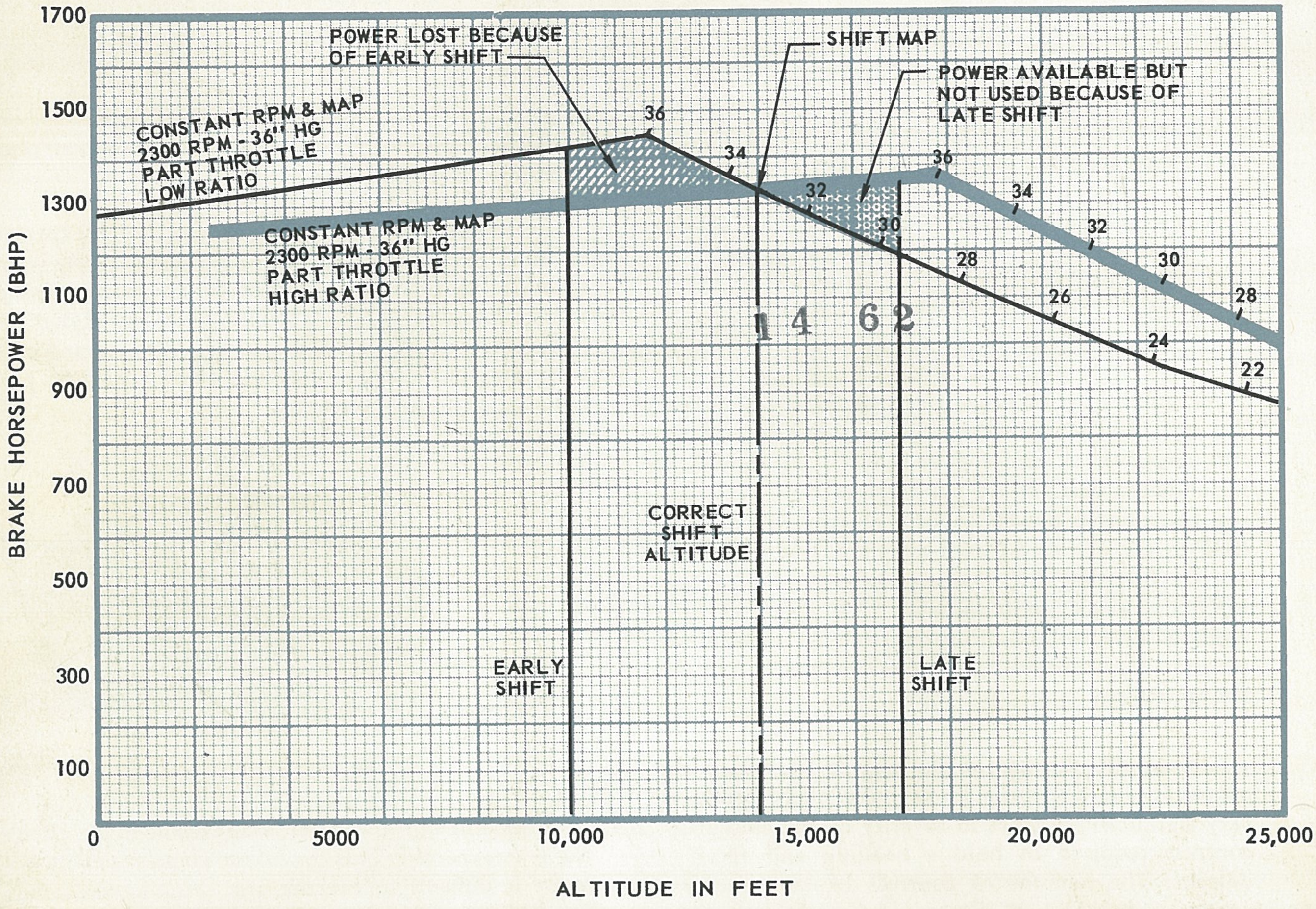
2. Immediately advance throttle of engine on which the tachometer does not drop to zero.

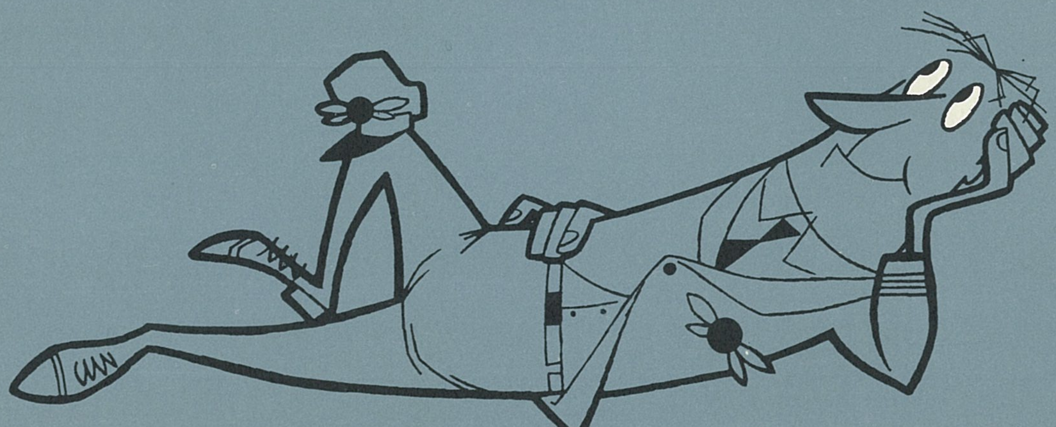
3. Feather propeller of engine on which tachometer reads zero.

Upon closing the throttles, if a propeller is in reverse, the engine will stall and then rotate backwards. In any case, the tachometer will not indicate engine rotation.

RESULTS OF SHIFTING TOO EARLY OR TOO LATE DURING CLIMB

R-2800-CB16 ENGINE
FUEL GRADE 100/130
BEST POWER MIXTURE





Convair TRAVELER

SEPTEMBER 1955
VOLUME VII
NUMBER 5

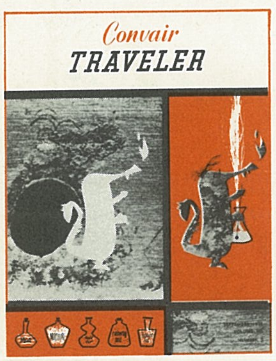
Convair TRAVELER

SEPTEMBER 1955
VOLUME VII
NUMBER 5

FOREWORD

All metals will corrode, the type and condition of the corrosion depending on a complex of environmental conditions and maintenance practices. The best assurance for maintaining the airworthiness and appearance of aircraft is a consistent and regular inspection routine, supplemented by corrective maintenance action, when necessary.

Although relatively few cases of corrosion have been reported on Convair 240's during approximately seven years of service, the experience gained with these aircraft provides information which may help operators of Convair 340 aircraft to obviate corrosion in similar areas.



ON THE COVER

Artist Willis Goldsmith has created Rusty, the little character who mixes his potent potions to spread on aircraft metals. Now you see him — now you don't.

Chief Engineer
R. L. Bayless

Chief of Service
J. J. Alkazin

Editor
G. S. Hunter

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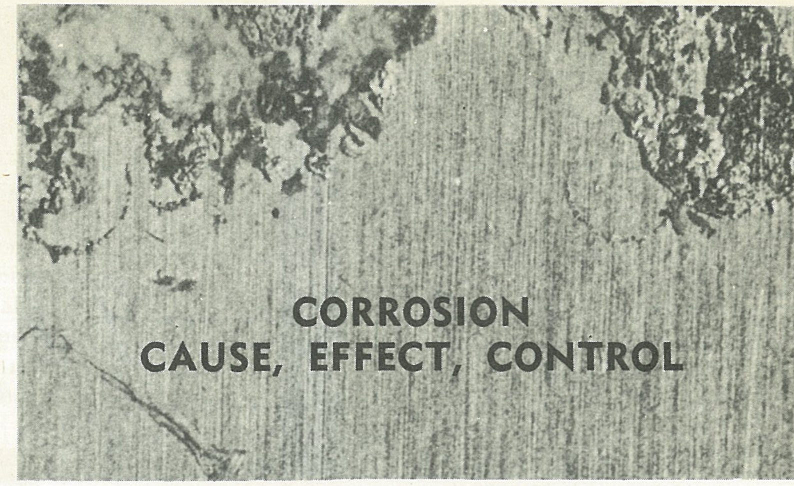
C O N V A I R
A DIVISION OF GENERAL DYNAMICS CORPORATION
(SAN DIEGO)



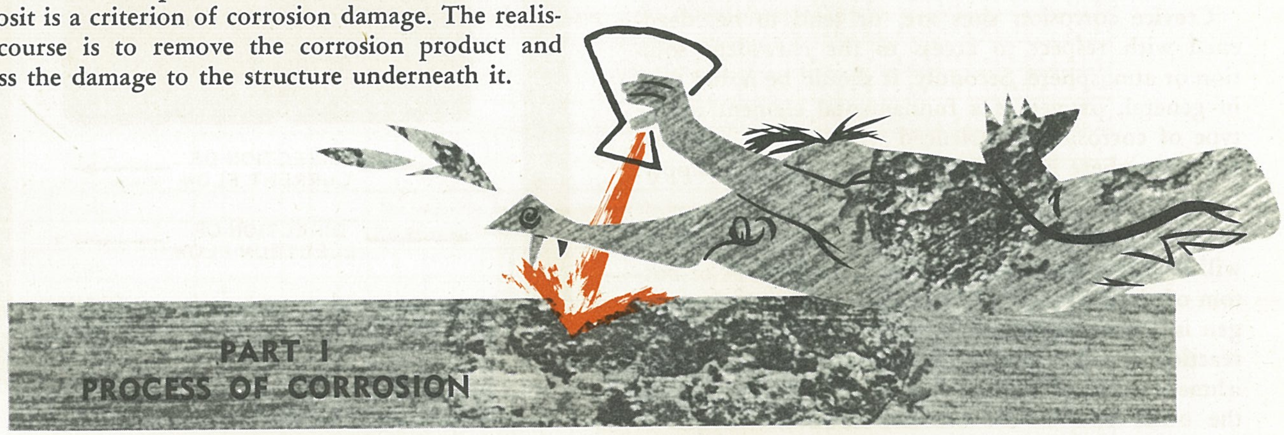
CORROSION CAUSE, EFFECT, CONTROL

All aircraft are exposed to a wide variety of corrosion-inducing influences. Among the foreign substances impinged on aircraft surfaces are moisture, salt air, mud, exhaust gases, and runway soils. Effects arising from these corrosive agents may be difficult to detect in terms of structural damage; however, they usually present early warning of their presence by the appearance of corrosion deposits.

The significant point evidenced by these deposits is that corrosive action is underway. Knowing this, remedial steps can be taken early to forestall the onset of serious damage. It is important to recognize that neither the presence nor volume of corrosion deposit is a criterion of corrosion damage. The realistic course is to remove the corrosion product and assess the damage to the structure underneath it.

Corrosion-proofing measures and systematic inspections are necessary to the control of corrosion damage. Corrosion, in spite of the many variables at work in its operation, is not a particularly difficult process to understand. Of consequence, however, is a proper understanding and effective preventative measures.

The identification of corrosive attack is a matter of close observation of the area of attack and its surroundings. For practical purposes, corrosive attack on airframe structures may be generally considered under four headings: Galvanic; Local Cell; Concentration Cell, or Crevice; and Chemical Attack.



PART I PROCESS OF CORROSION

LOCAL CELL CORROSION

This type of corrosion takes place at irregularly separate points on a metal surface. When it is allowed to progress, it penetrates into the metal in a damaging manner.

In simple terms, local cell corrosion may be described as galvanic corrosion acting on a microscopic scale. Its origin resides in the grain structure of the metal itself. In a simplified way, it may be pointed out that, when a metal freezes from its melted substance, the more pure portion freezes out first. As freezing proceeds, shells of less pure metal form around the nucleus until the grain completes its growth. Thus, the composition of a grain varies from its center to its boundary. This is sufficient to cause a galvanic difference to exist within the makeup of the grain. Since the parts of the grain are in intimate physical contact, electrical contact is established. Hence, when a suitable electrolyte (such as dirty water) contacts the grain, an electrical circuit is completed. In this case, the four elements of a battery are present, namely: a positive (anode) pole, a negative

(cathode) pole, an electrical connection, and an electrolytic connection. This "battery" is short-circuited and it exhausts itself in useless destructive action, otherwise known as local cell corrosion.

It can be seen then, that metals with greater purity are less susceptible to local cell action. As in the case of clad aluminum alloys, a covering of more homogenous high purity layer is applied to the less pure alloy core to combine the corrosion resistance of the former with the high strength of the latter. The alternative may be called the brute force method wherein chemically inert films such as oxide films (anodized surfaces) and paint films are used to exclude electrolytes from the metal. In electrical terms, this constitutes imposing an infinite resistance in the galvanic circuit to interrupt current flow.

CONCENTRATION CELL (CREVICE) CORROSION

Concentration cell, or crevice, corrosion, is found between faying surfaces of similar metals, at lap and butt joints, and at rivet heads. The basic corrosion process at work is essentially local cell corrosion. The distinguishing difference between concentration and local cell corrosion is the driving mechanism. Concentration cell corrosion may be said to be a consequence of the operation of the law of mass action.

Crevice corrosion sites are, or tend to be, deadened with respect to access to the corrodent solution or atmosphere. Secondly, it should be noted that, in general, oxygen is a fundamental element in the type of corrosion experienced with aircraft and that the atmosphere is the prime source of oxygen supply.

When crevice corrosion occurs, its action likely will manifest itself most acutely in the interior or bottom of the crevice. This takes place because the oxygen is consumed deep in the crevice in the corrosion reaction and, because of the inaccessibility of replenishment sources, falls to a low level in the locality. At the other end of the crevice, however, oxygen is plentiful.

Now, since a state of unbalance occurs at the inner and outer ends of the crevice, balance will be sought by carrying oxygen to the bottom. This, of course, will be consumed in the local cell actions, so it may be seen that a chain reaction in effect is in operation.

It should be apparent then that two devices help in averting crevice corrosion: 1) insulating the metals to prevent electrolytic contact, or 2) by filling the crevices with inert materials such as catalyzed rubber compounds.

GALVANIC CORROSION

Galvanic corrosion is an electro-chemical action which occurs in a galvanic cell. If this action is destructive, it is corrosive; if it is useful, it is termed battery action, as seen in automotive batteries, for example. A galvanic cell (figure 1) is comprised of four distinct elements: 1) a positive pole or plate, conventionally called an anode; 2) a negative pole or plate, conventionally called a cathode; 3) an electrical connection between the anode and cathode; and 4) an electrolytic connection between the anode and cathode.

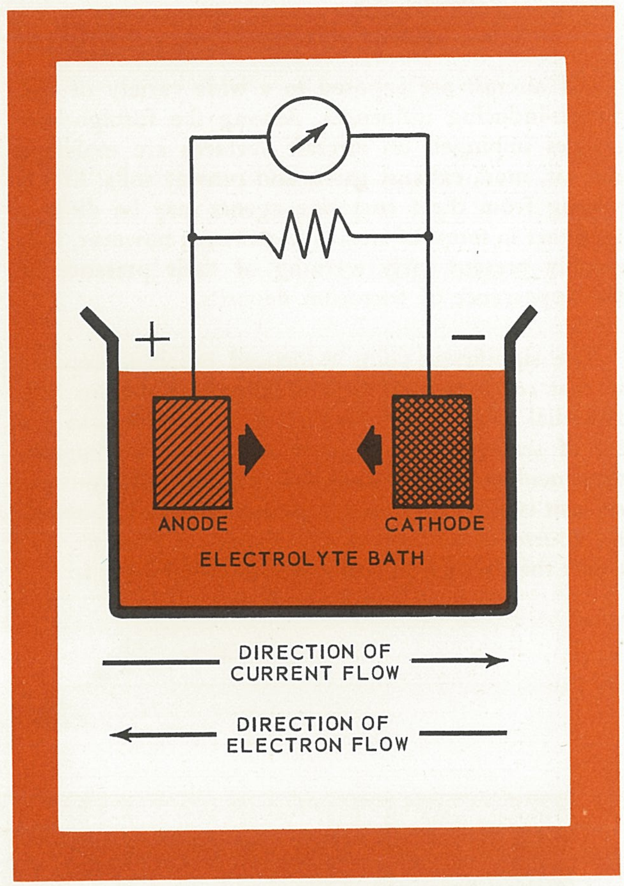


Figure 1

ANODES AND CATHODES When a galvanic cell is established, an electromotive potential, or voltage, will exist between the anode and cathode. If a variety of materials are examined in this manner and the voltage differences are listed and arranged in order, a regular series of numerical data can be accumulated. This already has been done under carefully standardized conditions to assure reproducibility of results. The resulting tabulation is called the electromotive force series of metals. A simplified form appears in figure 2.

POTENTIAL TENDENCY FOR GALVANIC CORROSION

ANODE
CORRODED END (LESS NOBLE)

CATHODE
PROTECTED END (NOBLE)

CATEGORY	METAL OR ALLOY	MAGNESIUM	MAGNESIUM ALLOY	ZINC	CLAD 75S	CLAD 61S	52S	CLAD 24S	3S	61S - T6	75S - T6	CADMIUM	A17S - T4	24S - T4	14S - T6	STEEL WROUGHT	STEEL CAST	50-50 SOLDER	LEAD	TIN	MANG. BRONZE	BRASSES	ALUM. BRONZE	COPPER	NICKEL	INCONEL	TYPE 410	TYPE 431	18-8 CRES	TITANIUM	MONEL	SILVER	GRAPHITE
	CATEGORY	1	1	2	3	3	4	4	4	4	4	5	6	6	6	7	7	8	9	9	10	11	11	11	12	12	12	12	13	13	13	13	13
1	MAGNESIUM	0	0	1	2	2	3	3	3	3	3	4	5	5	5	6	6	7	8	8	9	10	10	10	11	11	11	11	12	12	12	12	12
1	MAGNESIUM ALLOY		0	1	2	2	3	3´	3	3	3	4	5	5	5	6	6	7	8	8	9	10	10	10	11	11	11	11	12	12	12	12	12
2	ZINC			0	1	1	2	2	2	2	2	3	4	4	4	5	5	6	7	7	8	9	9	9	10	10	10	10	11	11	11	11	11
3	CLAD 75S				0	0	1	1	1	1	1	2	3	3	3	4	4	5	6	6	7	8	8	8	9	9	9	9	10	10	10	10	10
3	CLAD 61S					0	1	1	1	1	1	2	3	3	3	4	4	5	6	6	7	8	8	8	9	9	9	9	10	10	10	10	10
4	52S						0	0	0	0	0	1	2	2	2	3	3	4	5	5	6	7	7	7	8	8	8	8	9	9	9	9	9
4	CLAD 24S							0	0	0	0	1	2	2	2	3	3	4	5	5	6	7	7	7	8	8	8	8	9	9	9	9	9
4	3S								0	0	0	1	2	2	2	3	3	4	5	5	6	7	7	7	8	8	8	8	9	9	9	9	9
4	61S - T6									0	0	1	2	2	2	3	3	4	5	5	6	7	7	7	8	8	8	8	9	9	9	9	9
4	75S - T6										0	1	2	2	2	3	3	4	5	5	6	7	7	7	8	8	8	8	9	9	9	9	9
5	CADMIUM											0	1	1	1	2	2	3	4	4	5	6	6	6	7	7	7	7	8	8	8	8	8
6	A17S - T4												0	0	0	1	1	2	3	3	4	5	5	5	6	6	6	6	7	7	7	7	7
6	24S - T4													0	0	1	1	2	3	3	4	5	5	5	6	6	6	6	7	7	7	7	7
6	14S - T6														0	1	1	2	3	3	4	5	5	5	6	6	6	6	7	7	7	7	7
7	WROUGHT STEEL															0	0	1	2	2	3	4	4	4	5	5	5	5	6	6	6	6	6
7	STEEL CAST																0	1	2	2	3	4	4	4	5	5	5	5	6	6	6	6	6
8	50-50 SOLDER																	0	1	1	2	3	3	3	4	4	4	4	5	5	5	5	5
9	LEAD																		0	0	1	2	2	2	3	3	3	3	4	4	4	4	4
9	TIN																			0	1	2	2	2	3	3	3	3	4	4	4	4	4
10	MANG. BRONZE																				0	1	1	1	2	2	2	2	3	3	3	3	3
11	BRASSES																					0	0	0	1	1	1	1	2	2	2	2	2
11	ALUM. BRONZE																						0	0	1	1	1	1	2	2	2	2	2
11	COPPER																							0	1	1	1	1	2	2	2	2	2
12	NICKEL																								0	0	0	0	1	1	1	1	1
12	INCONEL																									0	0	0	1	1	1	1	1
12	TYPE 410																										0	0	1	1	1	1	1
12	TYPE 431																											0	1	1	1	1	1
13	18-8 CRES																												0	0	0	0	0
13	TITANIUM																													0	0	0	0
13	MONEL																														0	0	0
13	SILVER																															0	0
13	GRAPHITE																																0

The larger the number the greater the tendency for galvanic corrosion.

PROTECTED END (NOBLE)
CATHODE

1. Stainless steels, nickel and inconel are considered in the passive condition on the chart.
2. Each metal on the chart is considered anodic to the subsequent metals below it on the chart, left hand column.

Figure 2

By use of this table, the tendency for metals to enter galvanic action may be estimated since the greater the voltage difference between two metals, the greater their potential for corrosive action. Those displaying the least voltage difference in the tabulation are more apt to resist corrosion. The position in the tabulation itself does not automatically classify a group of metals as anodes or cathodes, but displays their tendency to assume these relations.

The combination of metals, experienced together with their environment, specifically determines the galvanic relation. In short, generalizations are to be regarded with a reasonable suspicion until evidence is at hand to bolster assumptions. The tabulation of potentials, thus, is included for general information.

ELECTROLYTES. Electrolytes, simply stated, are solutions which are capable of conducting electrical currents. Water is the most common solution; however, it is well to bear in mind that other materials such as alcohols, for example, can display the same characteristics.

Viewing this from a practical standpoint, water is the great energizer for corrosive action. A fundamental principle to observe is that so far as galvanic corrosion is concerned, dry objects do not corrode. Hence, the exclusion of moisture from dissimilar metal contacts is the most expedient method of corrosion control.

WATER IS THE GREAT ENERGIZER...

GALVANIC ACTION. As was pointed out, an anode and a cathode are integral parts of a galvanic cell. Collectively, these are known as electrodes. The electrochemical action manifests itself particularly at the contact of the electrodes and the electrolyte in phenomena characteristic of anodic and cathodic actions, also known as electrode reaction. See figure 1.

Briefly, the anodic reaction involves two basic actions:

1. *The transfer of electricity from metals in solution in the electrolyte (metal ions) to the anode.* It is not necessary that these metals in solution be the same as those comprising the anode or cathode.

2. *The transfer of metal from the anode to the electrolyte.* This is the action by which destruction is accomplished, since it is a literal tearing down of the anode.

Conversely, the cathodic reaction involves two basic actions:

1. *The transfer of metal from the electrolyte to the cathode.* In this action, hydrogen, a gaseous element, will act as a metal, collect on the cathode and prevent metal deposition. This is the type of action relied on to accomplish electroplating.

2. *The transfer of electricity from the cathode to the electrolyte.* Electricity flow is the movement of electrons, the unit particles of negative electricity. In this action, electrons move from the negative to the positive poles. It is to be noted that this is directly opposite to the conventional electricity flow from the positive to the negative.

Galvanic corrosion is an electrochemical phenomenon involved with the flow of electrical current. Both rates, and what may be called amounts of current flow, directly govern the progress of the galvanic or corrosive action. This is tied in directly with the electrode areas involved and also the relative areas of the active anodes and cathodes.

With respect to increases in area, it is common knowledge that a twelve-plate storage battery is more powerful than a six-plate battery. The same situation applies when galvanic corrosion cell electrode areas are enlarged. In this latter case, the battery energy is used up in corrosive work rather than in useful work, and damage may be reckoned in terms of area. With large electrode areas in action, heavy currents are generated in short times, electrochemical work is done rapidly, and it may appear that the formerly reliable materials are falling apart. The fact is that the materials have not changed, but their use has.

As has been mentioned, anodic reactions are destructive and cathodic reactions tend to be constructive. Thus, if the anodic reaction were duly distributed with respect to cathodic reactions, that damage may be limited to surfaces and restrained from boring into structures. This simply means that anodes should not be forced to carry heavy currents, if it is desired to avoid galvanic damage. Conversely, since cathodic reactions are constructive, it can be seen that cathodes can be made to carry heavy currents without damage. These observations are borne out in practice, and fortify the rule that corrosion-resistant structures should be designed with large anode areas and small cathode areas, relatively speaking, to minimize damage.

CHEMICAL CORROSION

Although galvanic or electrochemical corrosion is responsible for the major amount of corrosion damage on aircraft, there are instances where straightforward chemical action results in significant damage.

One immediate example is the action of battery acid on the structural metals. When this is splashed on the airframe, the sulphuric acid acts directly with the aluminum alloy, for example, to convert it into salt aluminum sulphate. The time-honored countermeasure is to paint the potentially affected areas with acid-resistant lacquer or enamel.

Another example where simple chemical action is involved is that where bromides are present. Bromine is introduced to the aircraft in anti-knock fluids used in engine fuel. When these fuels are burned in the engine, they are ejected in the exhaust. Where this directly impinges on the aircraft, bromine (bearing sooty deposits) may be found. When moisture comes in contact with these deposits, the bromine content is converted to hydrobromic acid by a process known as hydrolysis. In the acid form, the bromine attacks the metal. The apparent corrective lies either in the application of suitable moisture and acid-resistant paints to the affected areas, or incorporation of devices that will throw the exhaust gases from the airplane before they have a chance to impinge on it.

PART II
COMMON CLASSIFICATION OF CORROSION DAMAGE

Descriptions of the appearance of corrosion damage include five categories: Uniform Attack, Pitting, Intergranular, Stress, and Exfoliation. These terms are used to convey an observer's impression as to how the appearance of corrosion damage impresses him. Typical examples are illustrated in figure 3.

The expression, "Uniform Attack," merely states that corrosive attack is more or less uniform. It conveys little in signifying the intensity of attack which may range from a surface dulling to a substantial reduction of part thickness. Likewise, the expression, "Pitting Attack," conveys little significance.

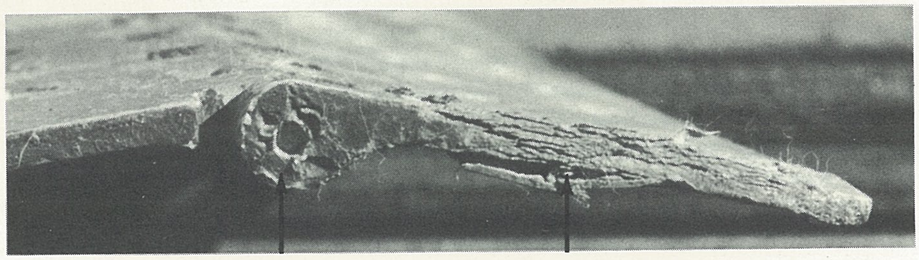
The term, "Intergranular Corrosion," also is basically descriptive but does convey some intelligence beyond the bold descriptive meaning. As stated previously, because of the workings of electrochemical laws, the grain boundaries are the weak link in the corrosion resistance chain. With this in mind and a case of intergranular corrosion at hand, two possibilities exist in causing the weak link to give way:

1. It may have been weakened during manufacture.
2. It may have been overstressed in service.

Now, when these suggestions have been made, the term, "Intergranular Corrosion," has significance.

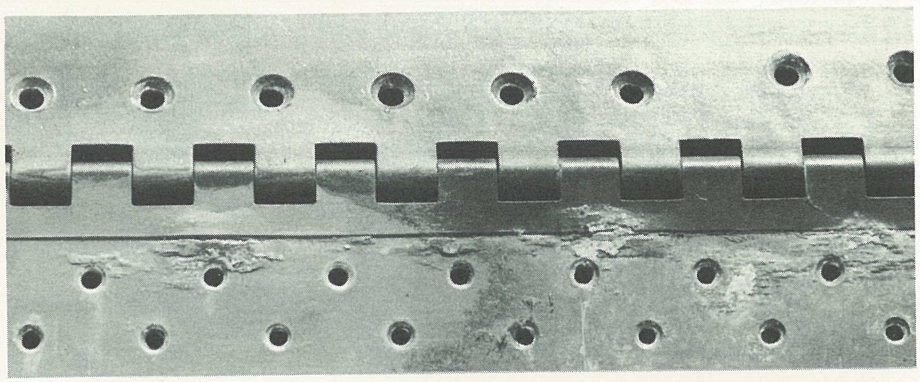
If poor heat-treatment is the cause of intergranular corrosion, it is necessary to subject an unaffected portion of the metal to examination to determine its condition. Should this examination indicate satisfactorily processed material, then the corrosion site should be examined to determine structural metal combinations, severe environmental exposures, or lack of adequate protective measures. Thus, it should be seen that Intergranular Corrosion can be combatted in an orderly and systematic manner to produce results which can effectively control the corrosion problem.

STRESS
AND
INTERGRANULAR



LOCAL
CELL
CORROSION

EXFOLIATION



CREVICE
CORROSION
IN
LAP
JOINTS

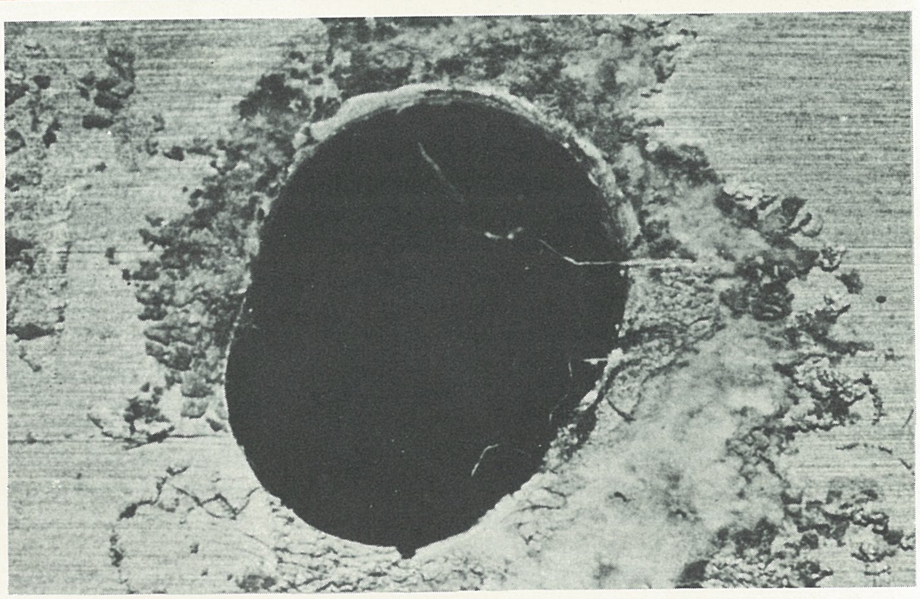


Figure 3

STRESS CORROSION[1]

Stress corrosion cracking is the spontaneous cracking which may occur in some alloys of almost any metal, under the simultaneous action of high prolonged surface stresses and corrosive environment. This phenomenon is loosely called stress corrosion. Two basic points are to be noted in this stress corrosion phenomenon.

1. A high enduring tensile stress must exist at the metal surface. The magnitude of the tensile stress required to produce stress corrosion cracking apparently varies considerably with the alloy and its environment.

2. A corrosive influence must be present. The particular nature of the corrosive environment required to produce stress corrosion also varies with the alloy.

It is generally agreed that in some way, the corrosion attack initiates small fissures principally in a direction generally perpendicular to the tensile stress. These tiny fissures cause a stress concentration at their base. This increased stress causes the fissures to open further, thus exposing fresh metal to corrosion attack. Finally, failure occurs by these mutually accelerating effects of stress and corrosion.

EXFOLIATION CORROSION

Exfoliation corrosion can be viewed as an exaggerated case of local cell corrosion. In the main, the operative corrosion mechanisms are identical in both cases. The significant difference lies largely in the size of metal grains occurring in the use articles.

Exfoliation is found chiefly on extrusions and forged billets. Further, it occurs only as a result of very severe corrosion conditions or prolonged exposure to these. Where metals themselves are basically responsible for exfoliation, faulty heat treatment usually can be clearly established as the offender, and corrective action is clear.

Corrosion may be retarded and minimized by alert maintenance personnel and good maintenance and inspection practices. Except for corrosion of faying surfaces, which is difficult to inspect because of inaccessibility, most corrosive attacks originate on visible surfaces and there is evidence on the surface when the attack is in progress. If allowed to progress, it will work into the base metal and destroy the mechanical and physical properties of the metal.

Above all, frequent and careful cleaning, immediate and complete removal of corrosion, and treatment of the affected area is most important in its control. Pertinent points and precautionary measures which help to eliminate or minimize corrosive attacks are tabulated on page 63.

When corrosion is discovered, it should be removed completely at the earliest possible opportunity.

LIGHT CORROSION

Light corrosion may be removed as follows:

1. Remove paint, if necessary, prior to removing corrosion products, with Turco Paint-Gon, or similar paint remover. Before repainting the surface, treat with Turco 2622C or 3002, which removes corrosion and passivates the surface in one operation. *Blistered paint indicates corrosion underneath.*

2. Remove all dust and dirt from the airplane.

3. Remove grease and oil from local areas with Stoddard solvent, and wipe dry.

4. Apply chromic acid solution (6 to $6\frac{1}{4}$ ounces to one gallon of tap water) to all unpainted aluminum alloy exterior surfaces.

[1]Dix, E. H., Jr. Trans A.S.M., Vol. 42, 1950, p. 1057-1125.

5. Apply with swab or spray, covering an area not over 10 feet square.

6. Rub with soft bristle brush (Palmyra or Tampico) to loosen any corrosion products remaining. A fiber brush is recommended. Metal brushes should not be used because bristles have been known to become lodged in lap joints and crevices, causing galvanic corrosion.

7. Allow acid to remain two to three minutes; then wash off with clear water. *Do not allow chromic acid to dry on surface because staining will result.*

SURFACE OXIDATION

Surface oxidation without heavy pitting is neutralized by application of Turco 2622C or 3002 to the affected areas. For large areas, the material may be applied full strength by spraying with a pressure pot and long handled spray jet. For small areas, the material may be mopped on the surface. Care must be taken to apply an even coating.

The brightener should remain on the surface for a period of 10 to 30 minutes until oxide coating is loosened and discoloration is removed. If material dries out before it can be removed, re-cover with a second coat of the brightener.

The rinsing operation is the most important part of the brightening procedure. A brush which has been dampened in water is used to brush the surface immediately ahead of the rinsing operation. It is desirable to have one man with a hose rinsing down immediately behind the one who is doing the brushing. It is important to brush all surfaces. Palmyra or Tampico brushes are ideal for this purpose.

HEAVY CORROSION

Heavy corrosion may be removed by rubbing with aluminum wool, using kerosene as a lubricant. If aluminum wool is not available, a find grade of garnet paper or other inert abrasive may be used. Caution must be exercised to avoid complete removal of the clad surface.

VAPOR BLASTING

Tests have been conducted by Convair to determine the efficiency of vapor blast for the removal of corrosion. Results obtained from these tests indicate that all corrosion may be removed with a negligible removal of metal. Since a metal surface will have an etched finish after vapor blast, it should be polished out to a smooth finish to reduce the possibility of continued corrosion in the affected area. Surfaces must be treated with chromic acid or Alodine 1200, as required.

Use of vapor blast is not recommended in areas where abrasive fluid run-off may damage equipment or bearing surfaces, or require clean-up procedures of disproportionate nature. Vapor blast should not be used in any fuel tank area where residual abrasive material could enter the airplane fuel system.

Satisfactory results are obtained only when process is closely controlled by qualified personnel. Improper use of equipment can result in excessive or complete removal of Alclad surfaces and subsequent need for replacement of skins or areas which have been improperly treated. It is possible that the precautions which must be exercised in the use of vapor blast may prove to be more costly than the present hand-rubbing method used for corrosion removal.

CLEAR COATINGS

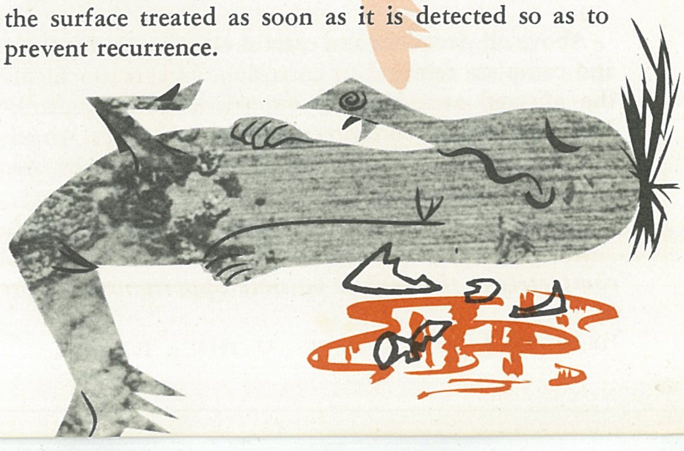
To retard corrosion, some operators spray their aircraft with a coat of Methacrylate clear lacquer (Du Pont No. 1202), or Du Pont Spray Glaze wax. These coatings, less than .001 inch thick, not only act as corrosion inhibitors but they eliminate the necessity for periodic polishing of the airplane.

SUMMARY

Corrosion should be avoided in all instances, if at all possible. Care should be taken first to select the proper material for the medium to which it will be subjected. Following this, a proper protective coating should be applied to the metal to eliminate any corrosion which might occur. It is important that surfaces be clean before protective coating is applied; otherwise, coating will not penetrate soil, or surface soil may absorb the coating.

Special attention and constant vigilance are required to guard against corrosion. Frequent and thorough cleaning procedures and inspection of likely areas serve to retard or minimize corrosive action.

If corrosion does occur, it should be removed and the surface treated as soon as it is detected so as to prevent recurrence.



MAINTENANCE AND INSPECTION HINTS FOR RETARDING CORROSION

1. Thoroughly check unpainted surfaces and touch up as required at each inspection period. Carefully check seams, lap joints, crevices, and other areas where moisture or dirt can collect. Areas subject to exhaust gases require close scrutiny.

2. Prescribe careful cleaning procedures to remove dirt and dust particles, because moisture tends to collect at these points.

3. Cover vent scoops when airplane is being washed.

4. Since moisture energizes corrosive action, thoroughly inspect areas where water is apt to collect after washdown. Wipe these areas dry, or dry them with an air hose.

5. Mask off magnesium parts when using brightening agents. These agents contain chemicals that attack magnesium alloys.

6. When inspecting areas containing control rods, bellcranks, quadrants, actuators, and sealed bearings, check for break in corrosion-preventive treatment.

7. Do not apply corrosion preventives over corrosion products.

8. Corrosion may attack metal even though it is painted since, upon prolonged exposure, moisture can penetrate the paint. Affected areas are characterized by a scaly or blistered appearance.

9. If battery acids are spilled, wash immediately with a dilute solution of sodium bicarbonate in water. After allowing to dry, remove all traces by thoroughly rinsing with water.

10. Thoroughly inspect all plated bolts before reinstallation. Scored bolts should not be reinstalled.

11. When sealing faying surfaces, be sure a small fillet of the sealant is exposed at the edge of the faying surfaces; when sealing butt joints, be sure space provided between joints is sealed.

9-55

Know-How

DESIGN HINTS FOR PROVIDING CORROSION-RESISTANT STRUCTURES

1. Plate or judiciously paint stainless steel parts in contact with aluminum so as to reduce corrosion of the aluminum.

2. Do not install small aluminum clips on large stainless steel webs. Use clips of stainless steel.

3. Use stainless steel fasteners in stainless steel assemblies in place of cadmium-plated alloy steel fasteners.

4. Use stainless steel hydraulic fittings with stainless steel tubing.

5. Insulate or isolate dissimilar metals wherever possible. If complete insulation cannot be achieved, use paint, plastic, or elastomers in the faying surfaces to increase the corrosion-resistance of the joint. Do not use wicking materials.

6. Anodize or passivate parts that are spotwelded (after spotwelding) where prior surface treatment is impossible.

7. Avoid absorbent materials in lap joints.

8. Seal edges of faying surfaces or butt joints with a sealing compound to prevent entrance of moisture in these areas.

9. Avoid curved areas, sharp corners, stagnant areas, and other areas where moisture and precipitants may accumulate.

10. Provide adequate drain holes.

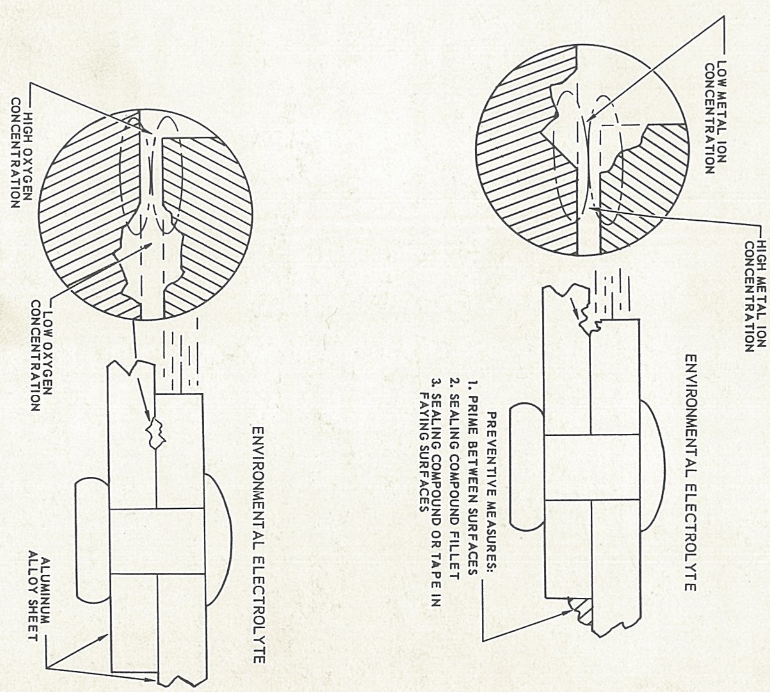
11. Paint all cut edges.

12. Select combinations of metals as close together as possible in the galvanic series.

SURFACE TREATMENT REQUIRED PRIOR TO FINISHING		
MATERIALS	INTERIOR	EXTERIOR
ALUMINUM ALLOYS: 2S, 3S, 52S, 53S, 61S AND CLAD ALLOYS	5% CHROMIC CHEMICAL FILM ANODIZE	5% CHROMIC
ALUMINUM ALLOYS OTHER THAN THE ABOVE BARE HI-STRENGTH ALLOYS	ANODIZE CHEMICAL FILM	ANODIZE CHEMICAL FILM
MAGNESIUM ALLOYS	CHEMICAL FILM	CHEMICAL FILM
STEEL, OTHER THAN STAINLESS	CADMIUM PLATE ZINC PLATE PHOSPHATE	CADMIUM PLATE ZINC PLATE PHOSPHATE
OTHER NON-FERROUS METALS SUCH AS COPPER, BRASS, BRONZE	CADMIUM PLATE ZINC PLATE	CADMIUM PLATE ZINC PLATE
STAINLESS STEEL	PASSIVATE CADMIUM PLATE	PASSIVATE CADMIUM PLATE

9-55

Know-How



CREVICE CORROSION
(Similar Metals)

Convair TRAVELER

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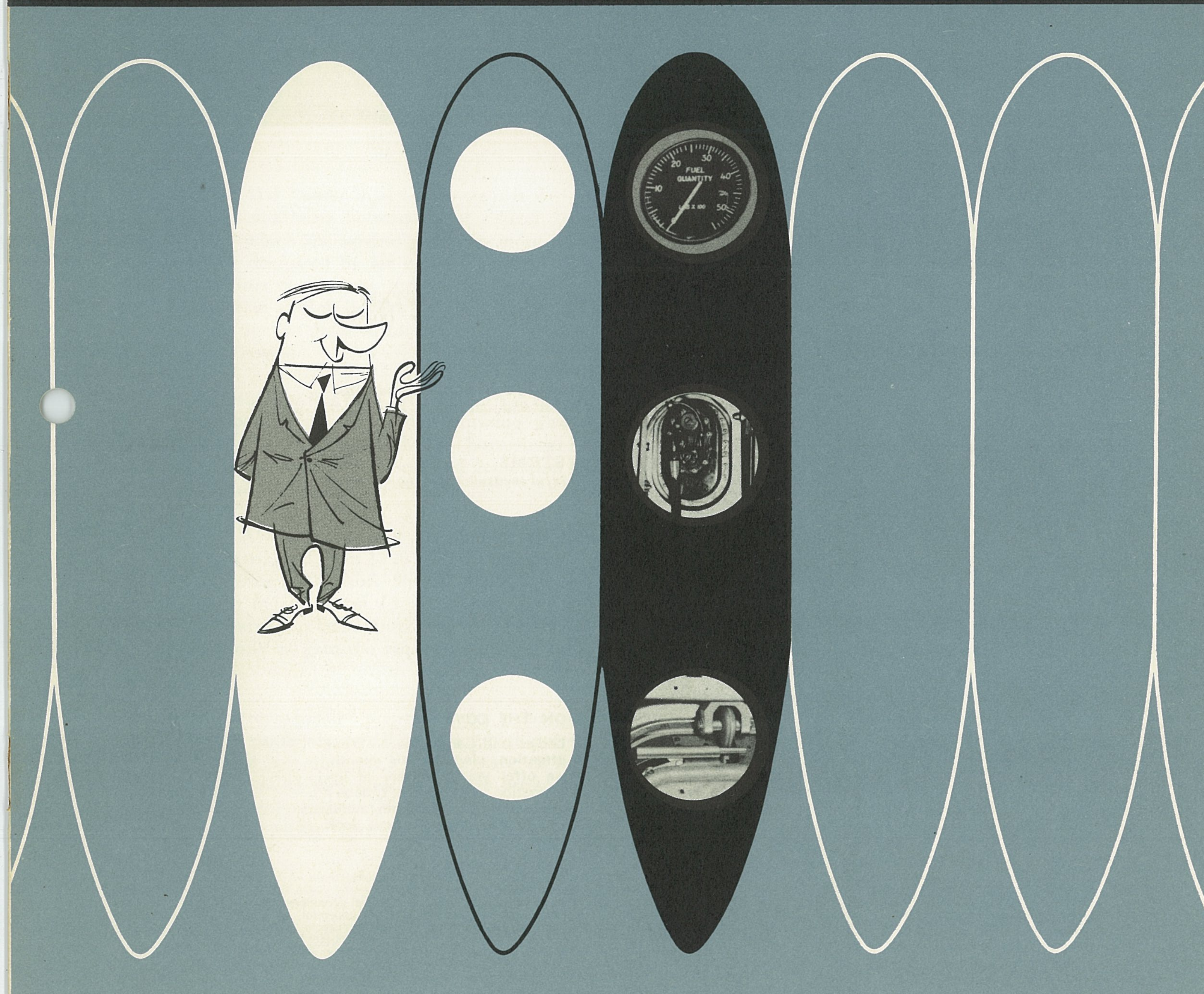

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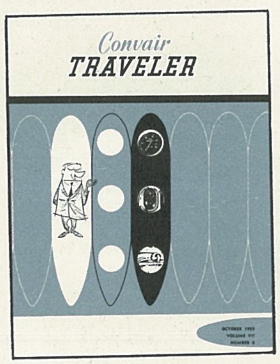


ON THE COVER

Ladies and Gentlemen — Your attention please. This month, we offer you a variety of information. If you can't determine the contents from Willis Goldsmith's cover, please look inside.

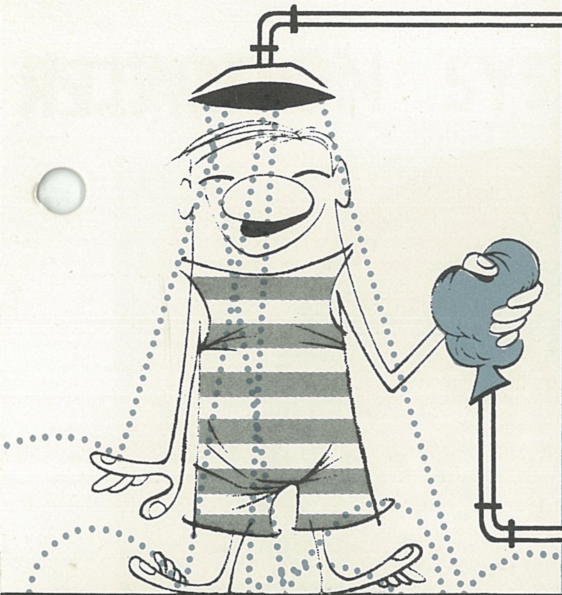
Chief Engineer
R. L. Bayless

Chief of Service
J. J. Alkazin

Editor
G. S. Hunter

A digest of Convair-Liner operation and service published monthly by the Service Publications Section of Convair in the interest of Convair-Liner operators. Communications should be addressed to Chief of Service, Convair, San Diego 12, Calif.

CONVAIR
A DIVISION OF GENERAL DYNAMICS CORPORATION
(SAN DIEGO)



MAINTAINING SERVICEABLE ADI SYSTEM

The ADI (water injection) system is designed to permit additional horsepower at takeoff, a period during which the engine generates more heat than can be dissipated by air cooling methods. Without water injection, excess fuel is required to suppress detonation at high powers . . . an amount that is far greater than is required for best fuel-air ratios, or required power.

By reducing this high fuel flow to the best fuel-air (horsepower) mixture, and substituting water injection for the excess fuel, additional horsepower is available for takeoff without heat and detonation damage to the engine.

The ADI pressure gage should read 32 psi maximum static, and from 22 to 25 psi when the regulator is metering ADI fluid. Should there be a pressure reading below 22 psi (flow conditions), the pump relief valve may be adjusted to raise the static pressure sufficiently to gain the required 22-25 psi flow condition.

The recommended pressures serve a dual purpose: 1) they insure adequate flow during high power operation and thus eliminate a possible marginal flow condition; and 2) they create a greater pressure spread between the minimum flow pressure limit and the pressure warning light switch settings.

To insure recommended pressure, make the following check of the system:

1. Run the engine up to 42-44 Hg M.A.P. with the ADI switch ON, and note fuel flow and BMEP. This power setting normally allows the regulator to meter an appreciable quantity of ADI fluid.

2. Maintain this power configuration, and move ADI switch to OFF position. Note fuel flow and BMEP. Normally, the fuel flow should increase because the derichment valve is now in the rich position; the BMEP should decrease because the mixture is now richer than the near best power mixture existing during derichment.

3. If there is no water flow at takeoff (wet power configuration), a marked head temperature increase will occur.

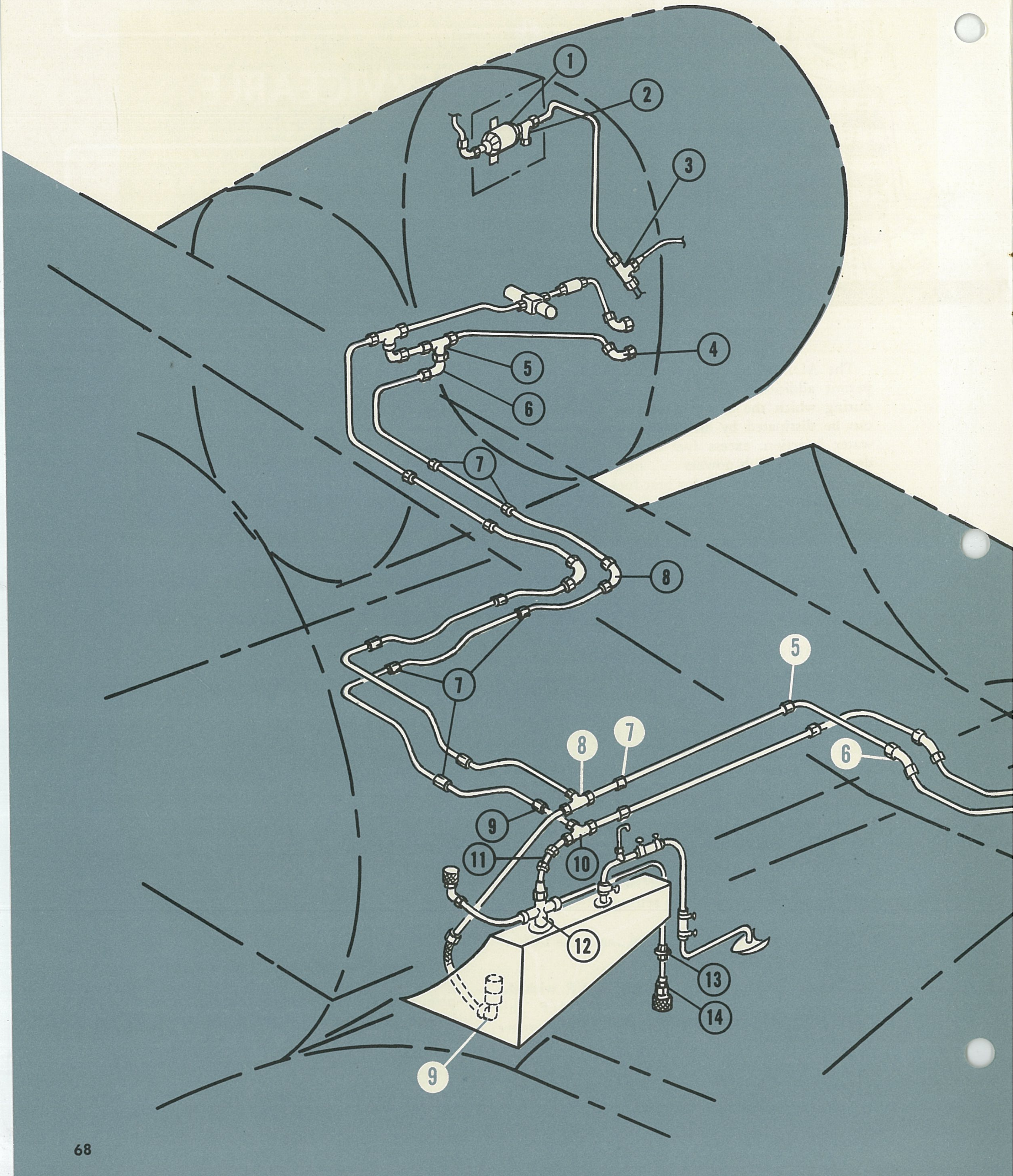
4. Further, a careful check of ADI fluid consumption should give a positive indication of normal or abnormal ADI system operation. Normal ADI fluid consumption is approximately 1.25 gallons per minute per engine at takeoff power.

5. Faulty pump operation or any restriction in the plumbing will be noted at the pressure gage.

To save weight, aluminum alloy fittings and 52SO tubing are used throughout the system, except at the fire wall where corrosion-resistant steel fittings are required. All aluminum tubing and fittings are coated with Alodine to minimize alkaline action of the methyl-alcohol on aluminum. To reduce solution potentials and prevent electrolytic action of dissimilar metals, the steel fittings at the fire wall are cadmium-plated. The cadmium plating also reduces the tendency of stainless steel threads, in contact with stainless steel threads, to gall.

When replacing tubing and/or fittings, it is important that only those fittings designated on the blueprint be used. Substitution of tubing and fittings that have not been treated may lead to reduced ADI fluid flow conditions.

The diagram on pages 68 and 69 is a guide to fitting requirements.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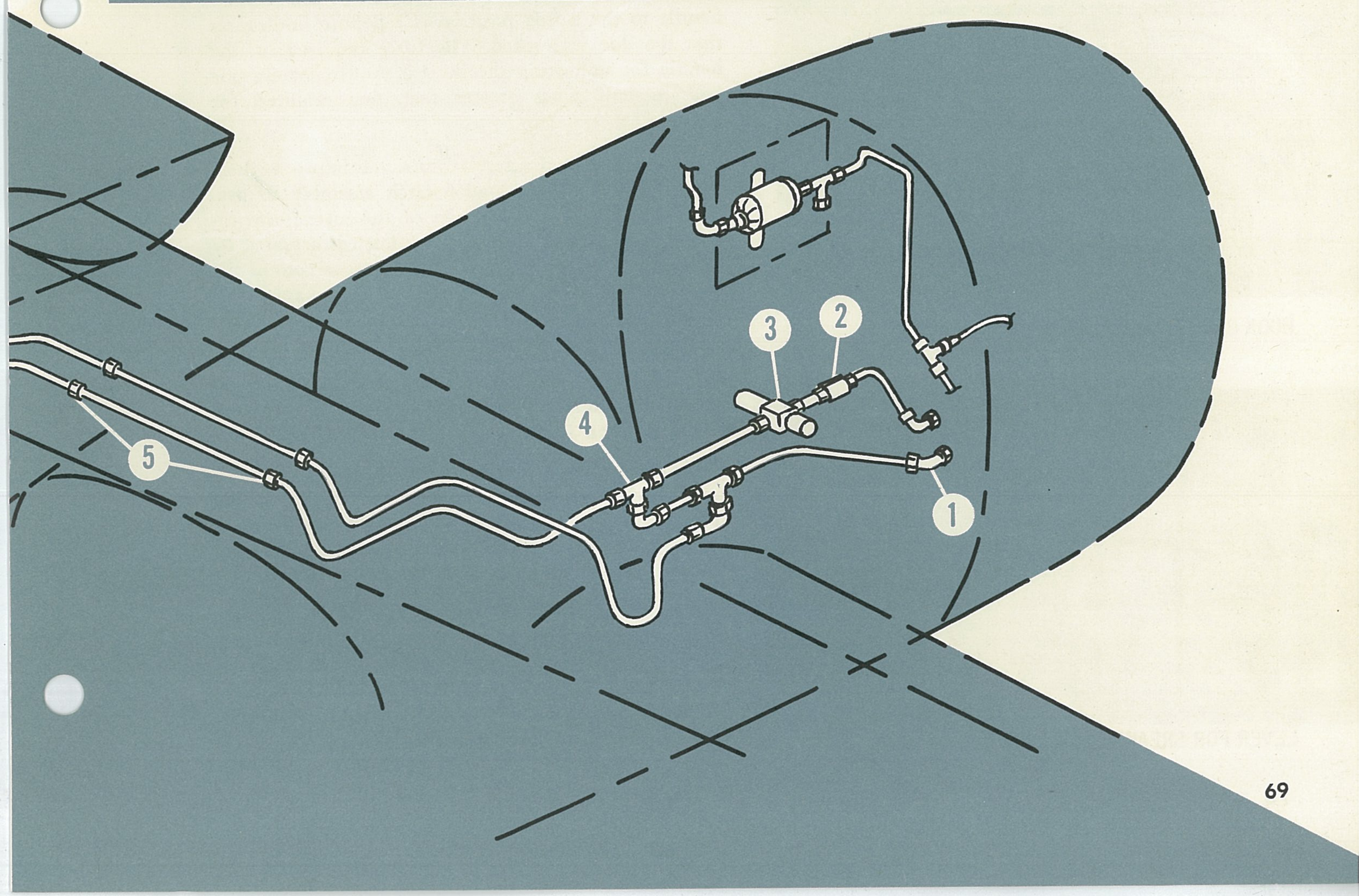
INJECTION SYSTEM TUBING REQUIREMENTS

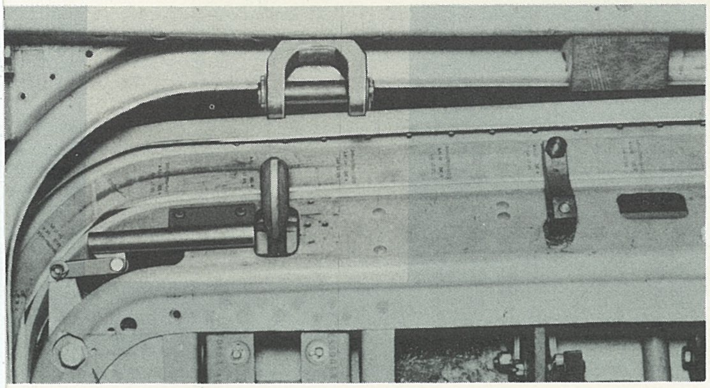
1. WATER PRESSURE WARNING SWITCH
2. TEE (AN826-4D)
3. CORR RES STEEL (CAD PLATE) TEE (FIT94-45), STEEL BULKHEAD NUT (AN924-4), CAP (FIT94-42), STEEL WASHER (AN960-7/16 - 2 REQ)
4. CORR RES STEEL (CAD PLATE) 45^{0} ELBOW (FIT94-18)
5. WATER-OPERATED CHECK VALVE (AIRITE NO. 1015B)
6. 90^{0} ELBOW (AN833-6D), BULKHEAD NUT (AN924-6D)
7. UNION (AN815-6D)
8. FUSELAGE PRESSURE SEAL FITTING (340-1610722)
9. REDUCER (AN919-18D)
10. TEE (AN824-12D)
11. FUSELAGE PRESSURE SEAL FITTING (340-3380701)
12. UNION (AN815-12D), FILLER TEE (340-8520011-11), O'RING (AN6227-14 - 2 REQ)
13. UNION (AN832-12D), NUT (AN924-12D), WASHER (AN960-D1716 - 2 REQ)
14. NUT (AN924-12D), NIPPLE, CAP

1. CORR RES STEEL (CAD PLATE) 90^{0} ELBOW (FIT94-44), STEEL BULKHEAD NUT (AN924-10), CARBON STEEL WASHER (AN960-1416 - 2 REQ)
2. CHECK VALVE (PARKER NO. 527-10D)
3. OIL-OPERATED SHUTOFF VALVE (WHITTAKER NO. W10100-10DA)
4. TEE (AN926-10D), UNION (AN815-10D - 2 REQ), BUSHING (AN893-121D), 90^{0} ELBOW (AN833-6D), BULKHEAD NUT (AN924-6D), GASKET (AN6290-10 - 3 REQ), GASKET (AN6290-6)
5. UNION (AN815-10D)
6. FUSELAGE PRESSURE SEAL FITTING (340-1610722)
7. REDUCER (AN919-22D)
8. TEE (AN824-12D)
9. 90^{0} ELBOW (AN822-10D)

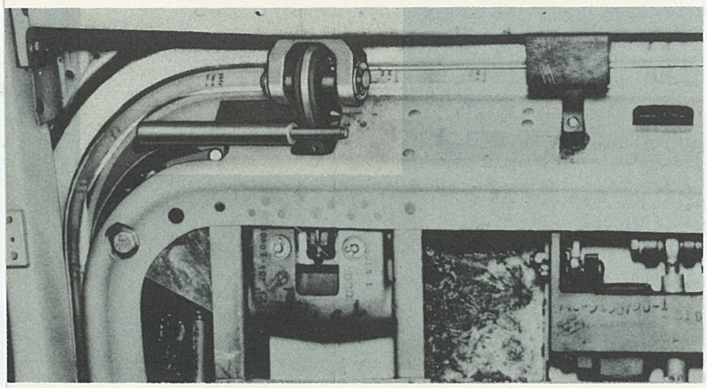
ALL ALUMINUM ALLOY FITTINGS AND 52SO TUBING ARE COATED WITH ALODINE.



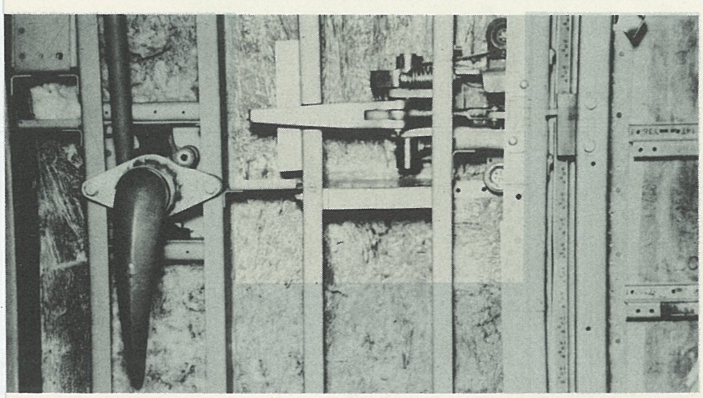
REAR SERVICE DOOR MODIFICATION



HOOK IN UNLOCKED POSITION



HOOK OVER YOKE; DRIVE PIN IN POSITION



LEVER FOR BREAKING HOLD-OPEN MECHANISM

Available in the near future for incorporation on Convair-Liner 340 aircraft is a new rear service door hinge and locking mechanism.

Positive door closed indication is provided by an auxiliary mechanism of the drive pin type which permits complete actuation of the locking handle *only* if all door hooks are correctly engaged in the yokes. During the door-closing cycle, the hooks rotate to the locked position, followed by movement of the drive pins into position behind the hooks. This sequence of operation is reversed during the door opening operation.

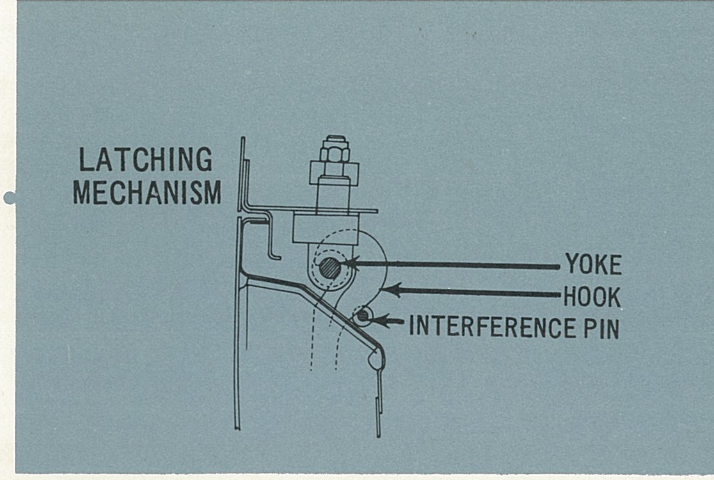
Incorrect positioning of the door hooks in the yokes will prevent full travel of the drive pins, thereby restricting movement of the door handle to a fully-locked position. Complete movement of the locking handle to the closed position is a definite indication that the door is locked. The force required on the handle for unlocking the door is approximately one and one-half times greater than that required for locking.

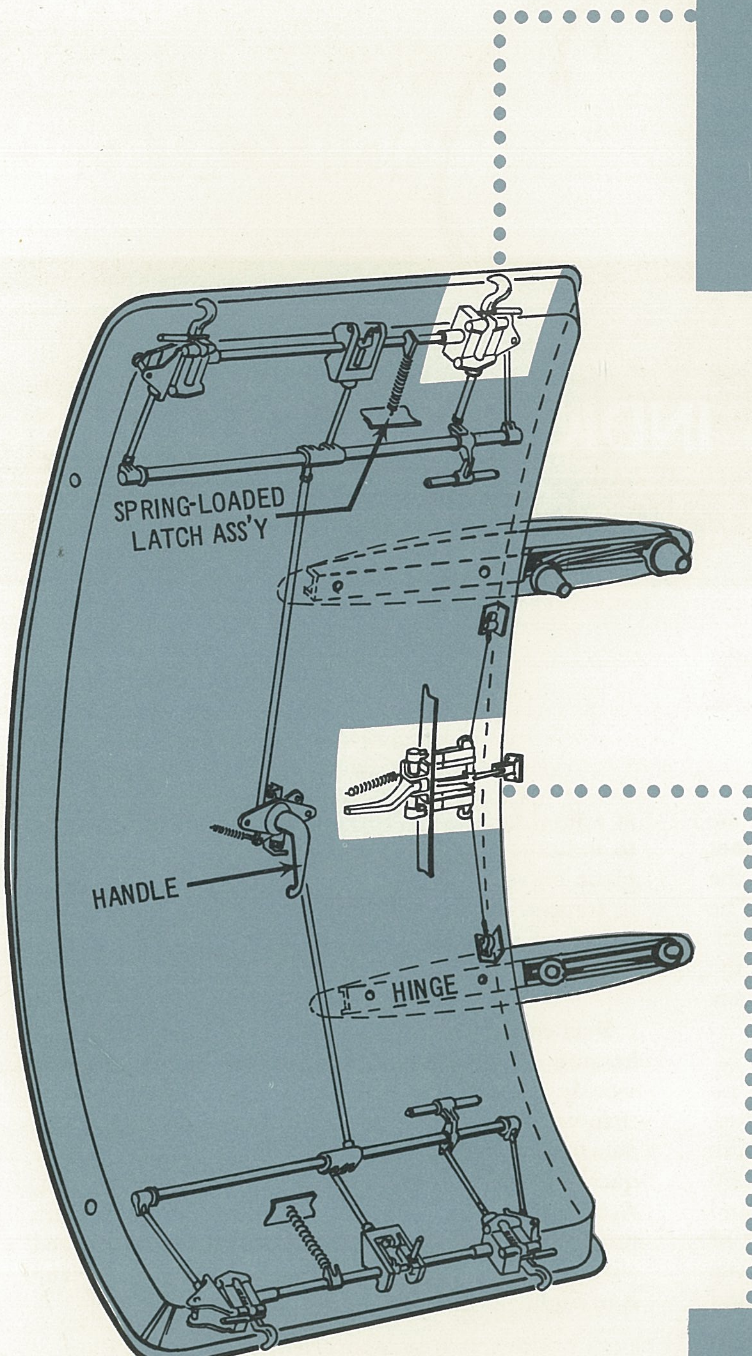
As an additional safety feature, the improved lock incorporates a spring-loaded latch assembly to preclude any vibrational rotation of the mechanism toward the unlocked position. This latch is actuated by a lost motion idler assembly through movement of the door handle. (See drawing of door mechanism on page 71.)

Two forward opening strap type hinges, one upper and one lower, replace the existing parallelogram hinges, providing a door that will trail in the near-closed position if it is inadvertently opened in flight.

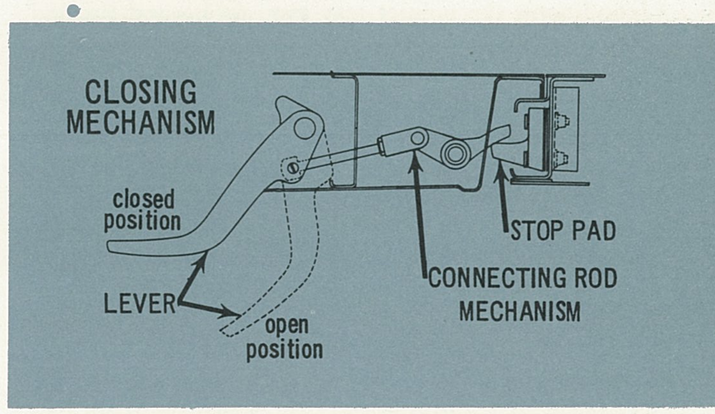
When the door is in the full open position, a hold-open mechanism prevents inadvertent closing of the door. Actuation of a lever, located opposite the door handle, "breaks" the hold-open mechanism so that the door can be operated from the airplane interior.

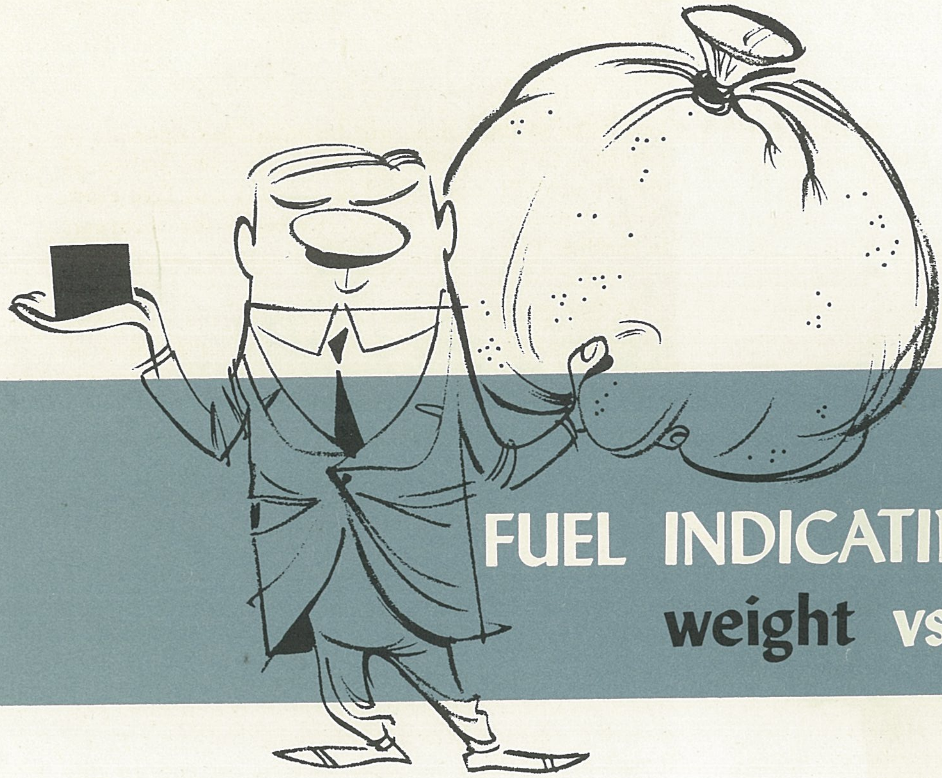
The new service door locking mechanism and door hinge are being incorporated on all Convair-Liner 440's in production. Those operators who wish to modify existing rear service doors of aircraft in service may obtain information and/or Service Bulletins and kits from the Parts Sales Department.





MODIFIED REAR SERVICE DOOR MECHANISMS





FUEL INDICATING SYSTEMS
weight vs volume

Dipsticks at one time were considered more accurate and dependable than fuel gages on airplanes but, with the improved accuracy obtainable from the capacitance type system, this is no longer true. The differences between indicator readings and dipstick readings are not necessarily causes for doubting the indicator . . . both may be correct, if the discrepancy is caused only by temperature effect.

With the capacitance type indicator, there is no fixed "full" point, because the weight of the fuel required to fill a tank depends on the temperature of the fuel. Thus, a tank which has a capacity of 9060 pounds at 77°F will hold 8700 pounds at 120°F, and 9600 pounds at —25°F. Therefore, the full point of a capacitance indicator will vary and, under extreme conditions, the pointer may even go beyond the end of the scale.

A capacitance type indicator should not be suspected of being out of calibration if it does not always indicate the same quantity when the tank is filled to the top. A capacitance indicator does not determine when the tank is full — it reports only the weight of fuel aboard. Whether or not the quantity is enough to fill the tank depends on temperature.

The fuel quantity indicating system on Convair-Liner 240 and 340 aircraft measures *weight* of fuel rather than *volume*. A dipstick, which measures fuel volume, measures fuel depth at only one position and at a level of 600 to 750 U. S. gallons. It is calibrated to indicate quantity of fuel in the tanks with the airplane on the ground in the static position. Fuel that is trapped below the level of the tank outlet, and therefore unusable fuel, is sometimes indicated on the dipstick.

Fuel capacitance gages are preferred over dipsticks because of their accuracy and dependability. As previously stated, they measure weight of fuel rather than volume, the weight being a more useful measurement than volume, because power available from any quantity of fuel correlates very closely with weight. Accurate fuel readings for flight plan purposes are provided with the indicator because it is calibrated according to calculated fuel depths when the airplane is in flight.

While temperature changes have considerable effect on the volume of fuel, capacitance type fuel quantity indication remains unchanged. As an example, an increase in temperature results in thermal expansion which raises the level of fuel between the tubes of the tank unit, and it also reduces the dielectric constant of fuel.

Note

Dielectric constant is a measure of non-conductivity of electrical current. The dielectric constant of fuel or oil is approximately twice that of air.

Tank units (capacitors), used to transmit fuel quantity information, are of the electronic, internally-mounted, probe type. Four such units are installed in each tank of the CV340 in order to keep error, due to change in normal airplane flight attitude, to within 3 per cent. Two such units are installed in each 240 tank. A fuel compensator also is installed at the inboard end of each tank in order to minimize change in the dielectric constant of the fuel. See figure 1.

Each capacitor is made up of two metal tubes, or conductor plates, one concentric within the other. The dielectric material between them is fuel or air, depending upon the level of fuel in the tanks. Since the size of, and the distance between, the conductor plates is fixed, the capacitance of the tank units can be varied only by changes in dielectric. Because fuel has twice the dielectric constant of air, the capacitance of the tank unit will increase as more of the conductor plate is immersed in fuel. When the tank is full, the entire dielectric material between the conductor plates is fuel, and the tank unit will have twice the capacitance it has with the fuel tank empty.

Measurement of the capacitance of the tank unit gives an accurate indication of the weight of the fuel in the tank, and is indicated on a dial in terms of pounds. Measurement is accomplished by means of a capacitance bridge circuit in which the tank unit to be measured is compared with another of known value.

The two capacitors are connected in series across a transformer secondary with a lead brought from a center tap on the winding to a point between the capacitors. If the center tap divides the voltage equally, and the capacitance of the tank unit is equal to that of the reference capacitor, the currents flowing in the two sides of the circuit will be equal, but opposite in polarity. In effect, the currents in the two halves of the circuit will cancel, and no current will flow from Point P to the center tap, indicated by the voltmeter in the line (figure 2).

As the quantity of the fuel between the electrodes increases (tanks are being filled), the capacitance of the tank unit also increases, resulting in a greater flow of current in the tank unit leg of the bridge. As a result, a current equal to the difference in currents in the two halves of the bridge and in phase with the current across the tank unit will flow between the center tap and point P, as indicated by the meter in the line.

If the quantity of fuel or oil between the electrodes decreases (tanks are being emptied), the tank unit capacitance also decreases, resulting in a smaller current flow in the tank unit portion of the bridge. The resulting current between the center tap and Point P will again equal the difference in currents in the two halves of the bridge, but the current in this instance will be in phase with that across the reference capacitor; that is, 180 electrical degrees out of phase with the current across the tank unit.

In practice, an amplifier connected between point P and the center tap amplifies any signal resulting from bridge unbalance, maintaining the phase relationship described. The output of the amplifier energizes one winding of the two-phase indicator motor; the other winding of the motor is constantly energized from an auto-transformer tap on the transformer primary, with the voltage shifted 90 electrical degrees by a fixed capacitor. As a result, the indicator motor is phase-sensitive; that is, it will operate in either direction, depending upon whether the tank unit capacitance is increasing or decreasing.

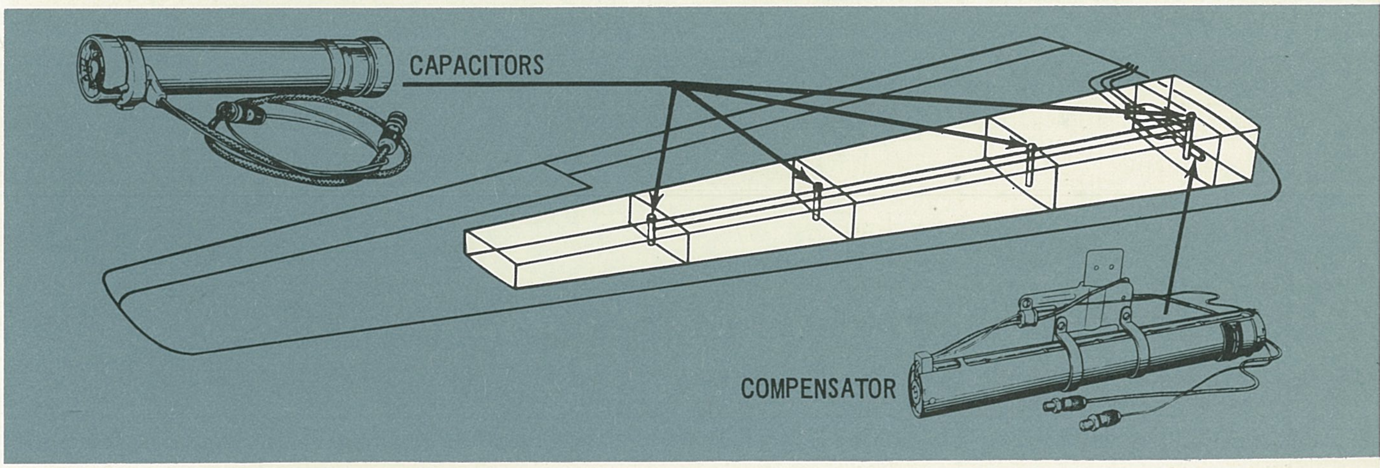


Figure 1. Minneapolis-Honeywell Fuel Gaging System as installed on the Convair- Liner 340

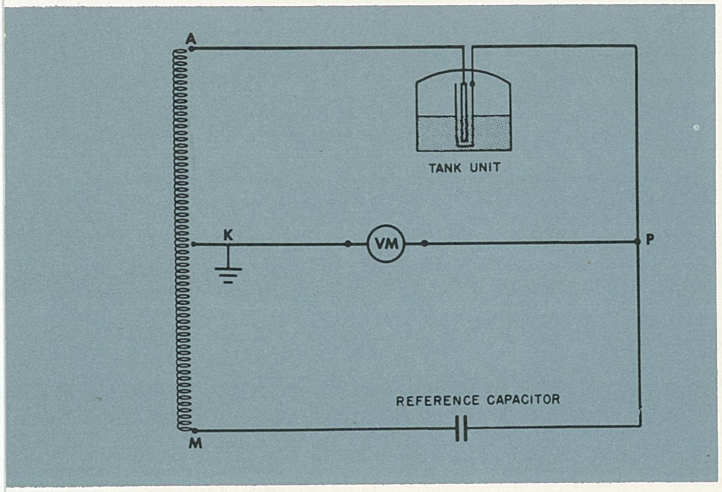


Figure 2. Simplified Bridge Circuit Schematic

In such a simplified bridge, the motor would run constantly except when the capacitances on each side of the bridge were equal. Instead of varying the reference capacitor to match each capacitance value of the tank unit, the same effect is obtained by varying the voltage applied to the reference capacitor by means of a potentiometer. (See figure 3.)

The wiper of this potentiometer is attached to the output shaft of a gear train driven by the indicator motor. The motor, activated by a signal generated by the unbalance of the bridge circuit, drives the potentiometer wiper in the direction necessary to restore the bridge to balance. When this point is reached, the motor stops, since there is no energizing signal. The pointer, which is coupled to the same shaft as the potentiometer wiper, then indicates correct fuel quantity.

Two other potentiometers, connected across portions of the winding at opposite ends of the transformer secondary, furnish a means of adjusting bridge voltages to balance over the *empty to full* capacitance range of the system.

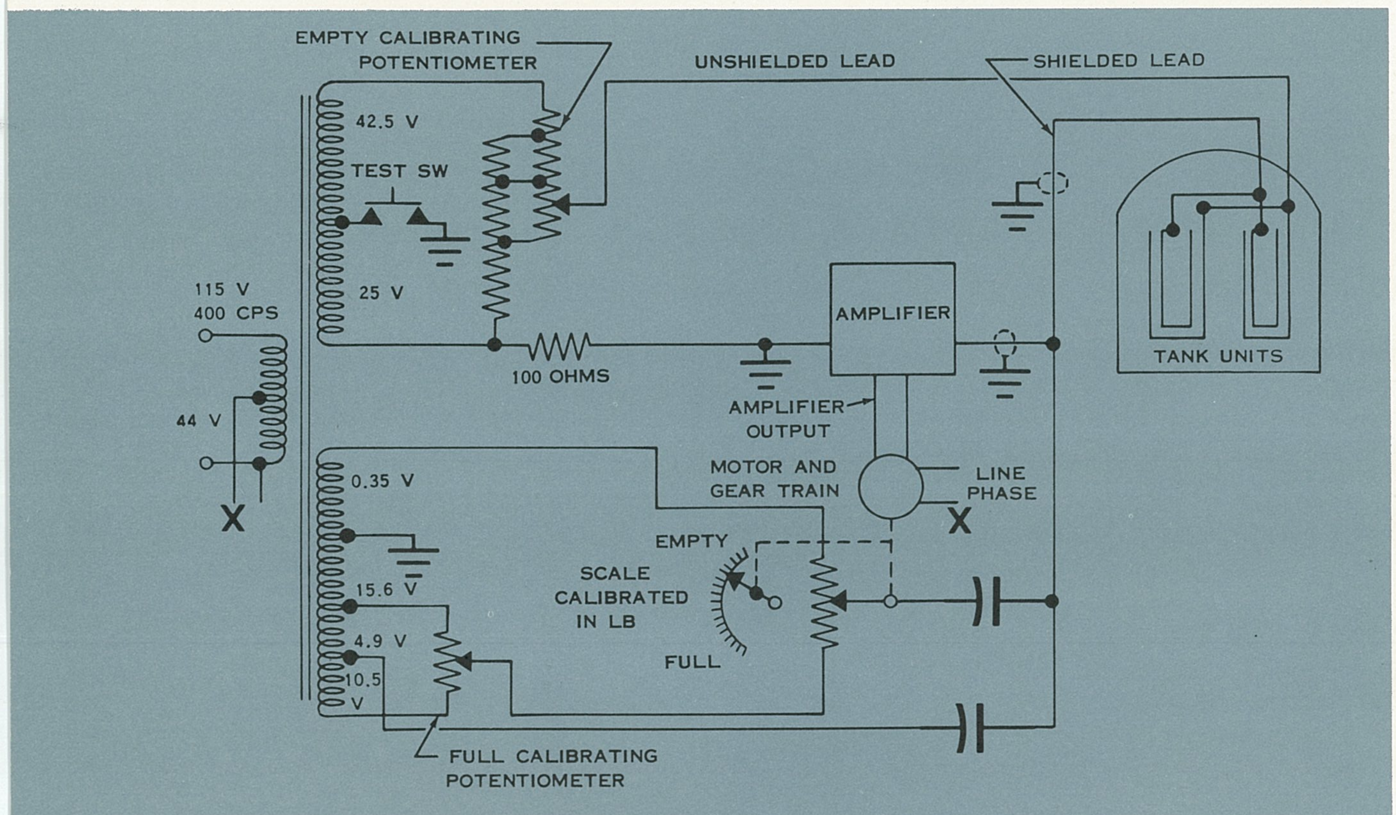
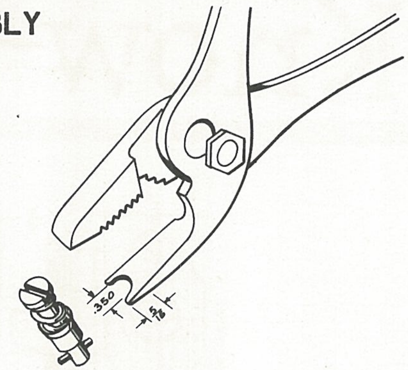


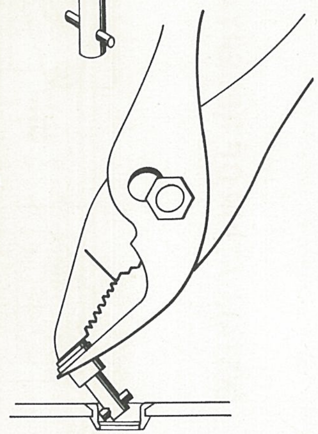
Figure 3. Schematic Diagram of Self-Balancing Bridge Circuit. *The diagram shows only two tank units. Actually, the number varies with the specific application. In order to minimize effects of sloshing or of changes in aircraft attitude, four tank units are connected in parallel on each side of the CV 340 fuel tank system. Only one tank unit is required for the oil gaging system.*

INSTALLATION OF STUD ASSEMBLY



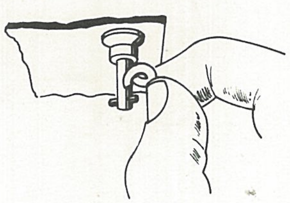
Camloc Stud Assemblies No. 4002-1 through No. 4002-15 are designed for instant installation or removal by use of special Camloc Pliers No. 4-P2.

Camloc Stud Assemblies No. 4002-16 through 4002-25 are held in place in Grommet by use of Washer No. 4002-A10L. Washer can be easily spread open by hand.



To insert Stud Assembly into Grommet, engage flange of spring cup in Camloc Pliers and squeeze Stud head against spring cup. Stud Assembly can then be inserted into Grommet. When spring is released, Stud Assembly will be securely in place. Stud Assembly can be removed in like manner.

Do not remove cross pin from Stud. Cross pin is factory installed to insure perfect fit and alignment. If damaged, replace complete Stud Assembly.



To install Stud Assemblies No. 4002-16 through No. 4002-25, insert Stud through Grommet. Open Washer enough to permit placing it around Stud shank between cross pin and Grommet. Flatten out Washer by use of pliers or fingers. Stud assembly may be removed by removing washer.

Note: When stud length is correct, the stud should be flush within ±1/64 inch after final assembly.

Know-How

CAMLOC FASTENERS

The Camloc fastener consists of three parts: receptacle, grommet, and stud assembly. The receptacles are of two general types; rigid mounting and floating receptacle. Both are available in either one-inch rivet hole centers, or 1-3/8-inch rivet hole centers. The floating receptacle permits a 1/16-inch play in all directions to compensate for hole misalignment between mating parts. The grommet is supplied in one type and size only.

1. On sheets up to and including .064-inch thickness, the sheet material should be dimpled.

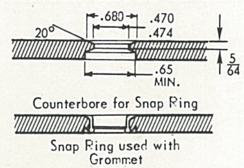
2. In sheets of .072- and .081-inch thickness, the sheet should be countersunk in order to mount the grommet; a snap ring is necessary to hold the grommet in place.

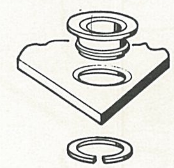
3. In sheets above .091-inch sheet thickness, the sheet should be countersunk in order to mount the grommet. If the material is counterbored, a snap ring is necessary to hold the grommet in place.

4. The spring-loaded stud is supplied as one assembly and it is not necessary to remove the cross pin in order to assemble the stud in the grommet.

INSTALLATION OF 4002-G GROMMET

For sheet thickness .091 and over, countersink and counterbore sheet as shown.

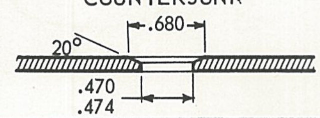


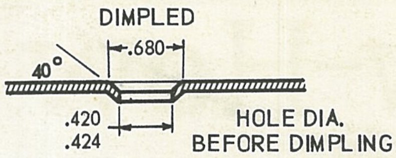


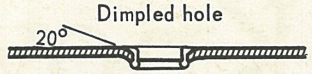
Insert grommet in hole and force snap ring over shoulder of grommet.

For sheet thicknesses of .072 and .081, countersink sheet. Use snap ring R-G4 over shoulder of grommet.

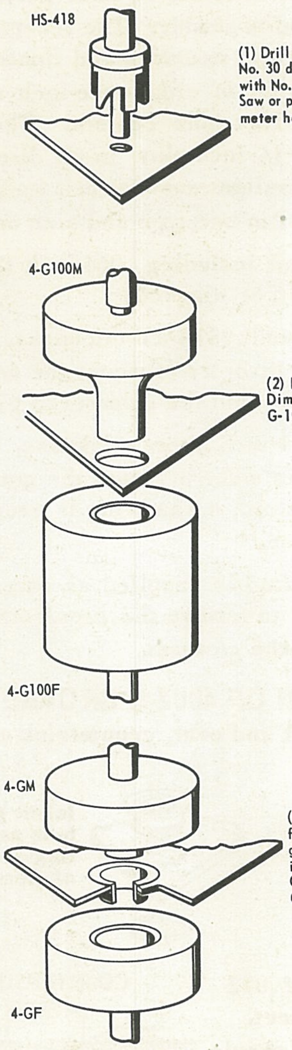
COUNTERSUNK







Grommet in dimpled installation



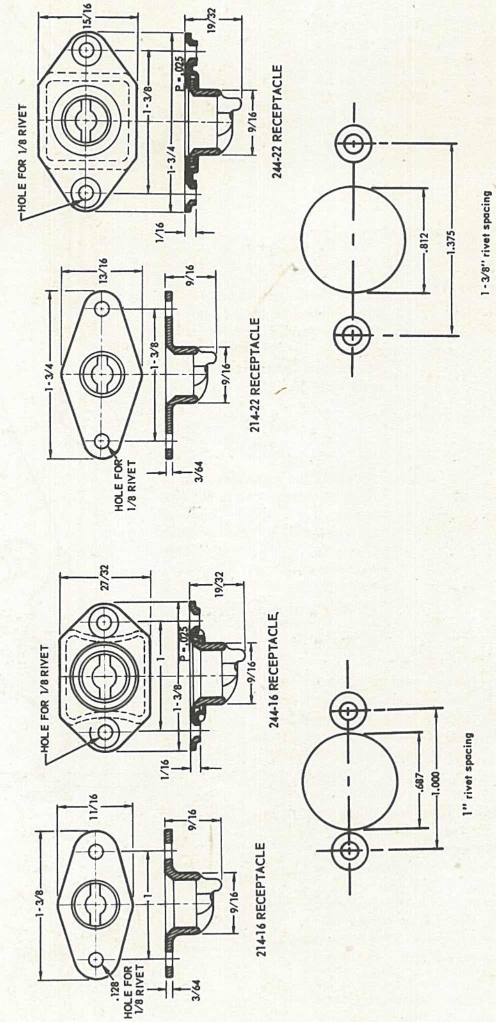
(1) Drill pilot hole with No. 30 drill. Enlarge with No. HS-418. Hole Saw or punch .420 diameter hole.

(2) Dimple with No. 4-G100M. Dimple Punch and No. G-100F Dimple Die.

(3) Insert grommet in hole from outside of panel. Lock grommet in place by flattening dimple with No. 4-GM Closing Punch and No. 4-GF Closing Die.

Know-How

INSTALLATION OF RECEPTACLE



Convair TRAVELER

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NUMBER 7

Convair
TRAVELER

NOVEMBER 1955
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NUMBER 7

FOREWORD

Augmentor tube cleaning procedures have been the subject of much discussion as has been the inspection and repair of these tubes. The frequency and method used for cleaning augmentor tubes is dependent upon the type of service and physical equipment available. In this issue we describe methods used by various Convair-Liner operators and the results they have obtained.

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ON THE COVER

To design a cover that has eye appeal and yet reflects the contents of an issue is no small task. Artist Jack Davis ably combines these two factors on this month's cover.

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C O N V A I R
A DIVISION OF GENERAL DYNAMICS CORPORATION
(SAN DIEGO)

AUGMENTOR TUBES

HOW TO IMPROVE SERVICE LIFE

The augmentor tube installation on Convair-Liner 240's and 340's is similar; thus, all replacements for either aircraft may be made with one tube configuration. The -314 tube has been the only tube manufactured for a number of years and, with very few exceptions, is in use on all Convair-Liner 240's and 340's. This tube has recently been replaced by the -330 tube to provide lugs for attaching the bellmouth on the CV340. When used on the CV240, the lugs for attachment are not required. This tube will be used for all replacements and eventually will become standard on all Convair-Liners.

The augmentor tube is considered a part of the engine exhaust system and must be maintained accordingly. Indications are that average total augmentor life on the 340, which now equals time of approximately 4000 hours, will continue to increase. It is entirely possible that the very small percentage of tubes requiring early repair may have had stresses induced during fabrication or handling, and past experience indicates that once they are relieved, cracks are less likely to recur.

Materials originally selected for augmentor tubes on the Convair-Liner 240 were of minimum practical gages to keep weight down. Although the tube is an integral part of the engine exhaust system and acts as a form of exhaust gas heat exchanger, it is fabricated of material considerably lighter than that used for a conventional exhaust system component. The light-gage augmentor would last no longer than a single flight if exhaust gases were not diluted with engine cooling air.

240-340 COMPARISON

Comparing the 240 and 340 engine installations, the CB16 engine requires more cooling air than the CA18 engine, if the same cylinder head temperatures are to be maintained. This in turn requires a greater pressure drop across the cylinders. If this is achieved by use of cowl doors, the ratio of exhaust gases to engine cooling air weight flow is increased, causing the tubes to be hotter.

The Convair 340 and 240 have a siamese exhaust manifold; originally, the CV240 had a triamese exhaust manifold. The siamese cluster has a diameter at the entrance to the bellmouth that is 2⅛ inches greater than the diameter of the triamese system at the same point.

In the Model 240 augmentor, the larger diameter of the siamese cluster causes the exhaust gases to be discharged closer to the wall of the augmentor. The temperatures in the inner tube at this point along the longitudinal seamweld, remain fairly constant as the gas and air mix and flow aft, while temperatures between the corrugated liner and the skin rise as the cooling air flows aft. The result is that the differential expansion of the inner corrugated skin and the outer skin is at a maximum at the forward end. The fact that almost all of the outer skin cracks in Model 340 aircraft appear in this forward portion of the tube establishes a correlation with this difference in temperature and expansion characteristics. Moreover, the larger augmentor vane on the Model 340 tends to force the tube temperatures higher in this area.

In comparing anti-icing air management, the cowl doors on the Model 240 are closed, and *then* the vanes are closed, as required, to obtain heating air flow to the leading edges. It is possible to close the vanes fully and still maintain satisfactory head tempera-

tures without opening the cowl doors. On the Model 340, the procedure differs. The vanes are first fully closed; the cowl doors are then positioned partially open, or as required to maintain cylinder head temperatures. (Mid position is the allowable maximum.) Excessive cowl door openings allow engine cooling air to spill overboard past the open cowl doors.

It is believed that even though there are differences in power plant operation of 240 and 340 aircraft, these differences do not warrant a different type tube for each aircraft. Although some 340 operators have had difficulties with the -314 tube, others have had service comparable to that obtained with the -260 and -314 tubes on Model 240 airplanes.

Tube failure rates on early Convair-Liner 240's were serious. After extensive testing on the stand and in service, Convair developed the -260 tube, and later the -314 tube, both of which are giving satisfactory service life. As with other tube configurations, there was no assurance that the -260 and -314 tubes would be satisfactory; however, after a period of daily flashlight inspections and frequent intervals of wire brushing, operators were able to determine suitable inspection and overhaul periods.

Some Convair 340 operators who were not satisfied with the service received from the -314 tubes conducted flashlight inspections similar to those conducted on early 240 aircraft, and reviewed operating procedures. There have been many indications that adherence to Convair recommendations has greatly eased difficulties that were encountered with the -314 tube.

OPERATING TECHNIQUES

In order to improve the service life of augmentors, there are many channels to be explored. One of the main factors influencing the life of augmentors is the behavior of the power plant, afterburning imposing the most severe operating conditions.

Intermittent afterburning may not cause the augmentor vane to trail even though the heat rise in the forward end of the tube is sufficient to cause localized damage. Continuous afterburning causes a rapid heat rise and, if this condition is allowed to continue, substantial damage to the augmentors can result. Even though the heat rise is rapid, there is a time lapse of several seconds before the augmentor vane will actuate.

Slight or intermittent afterburning may be detected by a popping noise in the augmentors; heavy or continuous afterburning may cause a steady rumble in the augmentors.

Fundamentally, afterburning is controlled by mixture and/or augmentor vane management. Abnormally rich carburetor mixtures may cause slight afterburning even with the augmentor vanes in trail. Such mixtures with closed augmentor vanes may cause heavy afterburning.

The problem of afterburning and augmentor tube overheating, which has resulted in several augmentor tubes being removed from aircraft due to melted silver solder or wrinkled skins, is at this time believed to be a direct result of misunderstanding by flight and maintenance personnel in regard to proper operation of cowl doors and augmentor vanes.

Service experience also establishes the importance of engine maintenance. Excessive ejection of combustible materials into augmentor tubes, due to carburetor or oil system malfunctioning, and ignition difficulties can also cause augmentor system overheating.

1. Do not close augmentor vanes during ground run-up as a means of shortening the warm-up period.

2. During normal flight, observe the published Pratt and Whitney recommended manual carburetor mixture leaning procedures at climb and cruise powers.

3. At low ambient temperatures, obtain maximum cabin heat available through closing cowl flap doors before using augmentor vanes to increase heat supply.

4. When ambient conditions are such that anti-icing is required, the augmentor should be closed and cylinder head temperatures maintained between 200° and 232°C by opening the cowl doors. Excessive cowl door openings with closed augmentor vanes will result in 1) lower cylinder head temperatures, 2) higher augmentor tube temperatures, and 3) less heat anti-icing because of the reduced air flow through the tubes and heat ducts.

5. During descent, if cylinder head temperatures cannot be maintained with cowl doors closed, it is permissible to close augmentor vanes as required to reduce air flow across the cylinders and raise head temperatures.

6. Limit functional checks of augmentor overheat switches to bench or static ground test, and avoid deliberate triggering of this system to functionally check overheat protection in flight.

An augmentor that has been subjected to heat great enough to melt the silver solder could very well result in additional damage. Accordingly, any augmentor upon which repairs of this nature are contemplated must be subjected to a thorough inspection. Even where cracking or buckling has not occurred, if the heat has been great enough to adversely affect the metal structure, the resultant service life of the augmentor may be jeopardized.

A stagnant air condition in the augmentor exists whenever the heat source valves are closed. Further, this stagnant air condition can be considered to actually lengthen the augmentor tube service life. This theory can be explained by realizing that there will be less temperature differential between the augmentor inner and outer skins if there is no air flow between them. Conversely, opening the heat source valves results in a greater heat differential between the inner and outer skins because of the resultant airflow, and causes a condition of unequal expansion. Outer-skin cracking could be hastened by this action.

CLEANING

Augmentor tube cleaning procedures have been the subject of much discussion as has been the inspection of these tubes. Again, the frequency and method used for cleaning the tubes is dependent upon the type of service and physical equipment available.

One European operator brushes tubes at 100-hour intervals. Although only 20 minutes per tube is required for cleaning in this manner, it is necessary to remove the tail pipe which results in high expenditure of man-hours. Operators who clean tubes by wire-brushing between engine overhauls, consistently report excellent service life from early model tubes . . . tubes that were considered unsatisfactory by operators who cleaned tubes only at engine overhaul.

Domestic operators, for the most part, make no effort to clean augmentor tubes between engine overhauls. At engine overhaul, they are removed from the airplane and thoroughly cleaned in tanks. One domestic operator removes tubes for inspection, cleaning and repair at 2100-hour intervals (periodic airframe inspection period). Engine changes are accomplished at 1400-hour intervals.

A typical tank cleaning operation follows the pattern set up by an operator of a large fleet of Convair 340's. When an airplane arrives at the overhaul depot for airplane inspection, the cowling, engine assemblies, and augmentor tubes are removed prior to placing the airplane in the work docks. The engine cowling and augmentor tubes then go directly to the cleaning shop and the airplane goes to the cleaning dock where the exterior of the airplane and the interior of the nacelles receive chemical cleaning.

Two large tanks are used for the augmentor cleaning process—one for the chemical and the other for rinsing. The tanks are approximately 16 feet long, 4 feet wide, and 30 inches deep, each with a capacity of 1178 gallons.

Protective clothing for personnel in the cleaning shop consists of rubber gloves, rubber boots, rubber aprons, and goggles, or face shields. Suitable precautionary placards are posted in conspicuous places. The cleaning shop is separated from other parts of the hangar so there is no need for special protection for adjacent shop areas, other than an adequate ventilation system.

The one tank is filled with a solution of 32 ounces Oakite Stripper M-3 to each gallon of water, with 1% Oakite additive. This solution is tested once a week and brought back to strength by adding more Oakite. A hopper in one end of the tank collects sludge which is removed with a shovel when the tank is drained and cleaned.

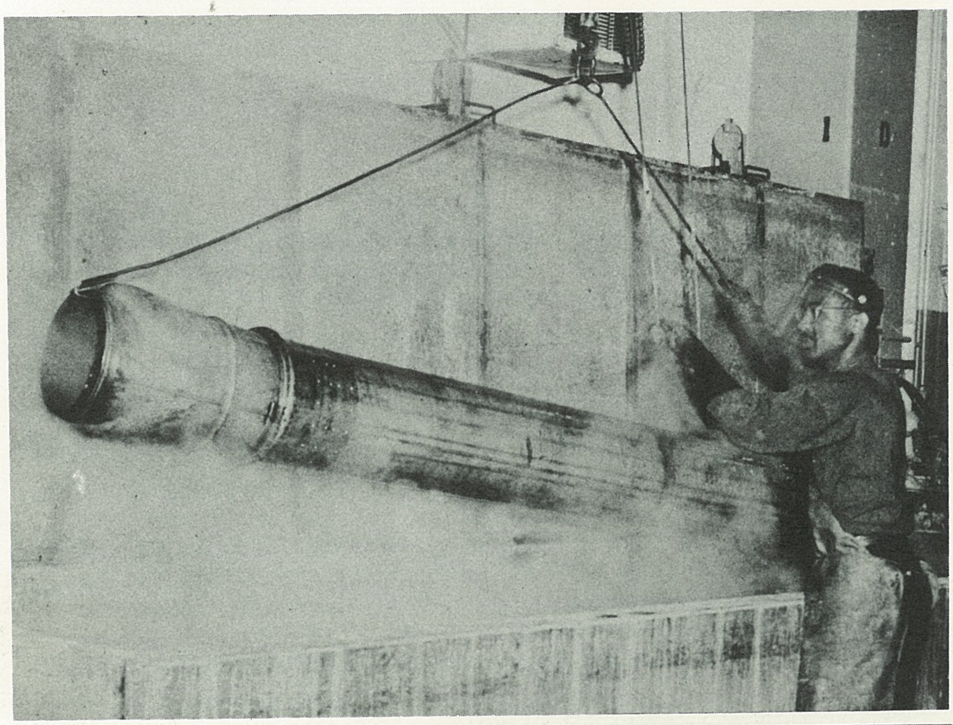
The temperature of the solution is maintained at approximately 220°F by a bulb thermometer installed inside a tube which is filled with oil. This is installed in one end of the tank and controls a steam valve to maintain the proper temperature. The solution is

heated by steam blankets installed on two sides of the tank. These blankets are approximately six feet long and are located at the center of the tank on each side.

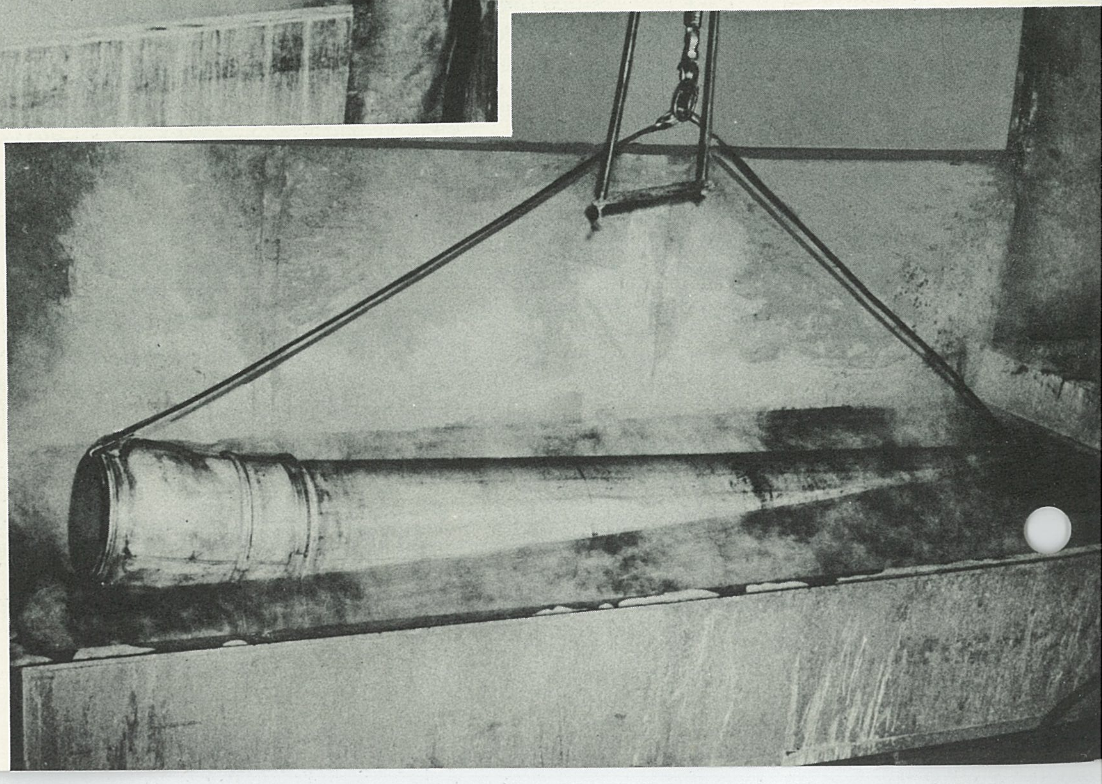
Tubes are removed from the cleaning tank and immediately placed in the rinse tank. Handling is by means of an electric hoist which travels on a monorail. Water enters the rinse tank through a ¾-inch line and overflows through a 1¾-inch line on the opposite side of the tank. Tubes are lifted from the rinse tank and washed down with hot water and steam under pressure. Carbon that cannot be removed from the inside of the tube is removed with a wire brush. Chunks of carbon that the brush does not remove are removed with a scraper, which is made to fit the corrugations.

Another domestic operator uses a solution of Turco 1662 (Supertrol) in proportions of 10 ounces of Turco to one gallon of water. (A mixture of 8 ounces of Supertrol to one gallon of water will clean the tubes, but it soon becomes too weak to work effectively.) As the solution is lost by evaporation or otherwise, it is replaced with more solution of the same strength. The solution is kept at a temperature of 180° to 200°F.

This operator also loosens deposits with high-pressure hot water or steam. Stubborn carbon deposits are removed with Turco L-780 and a wire brush or steel wool. When all carbon deposits are removed, the tubes are thoroughly rinsed with clear water at a temperature of at least 140°F. The tubes are hand-scrubbed inside and out. All carbon and debris are removed, facilitating inspection for cracks.



Tube is lifted from cleaning tank by electric hoist; it then travels on monorail to rinse tank.



Rinse tank is adjacent to cleaning tank so that tube can be immediately dipped; thus, parts are rinsed before solution has chance to dry.

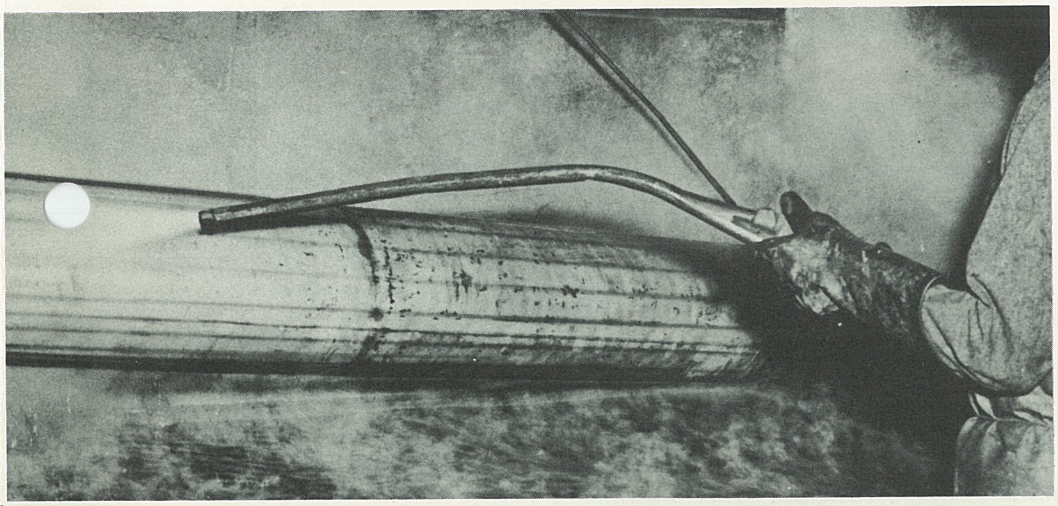
Another Convair 340 operator has established a 1500-hour interval for cleaning tubes, but such circumstances as nacelle afterbody repairs alter this period since it is considered poor economy to reinstall tubes with several hundred hours service without cleaning them.

Another operator removes tubes every 3000 hours. They are wire-brushed and inspected every No. 2 (375-hour) inspection; a more thorough inspection is accomplished under the forward blanket every 1500 hours. Inspection is by means of a flashlight and mirror.

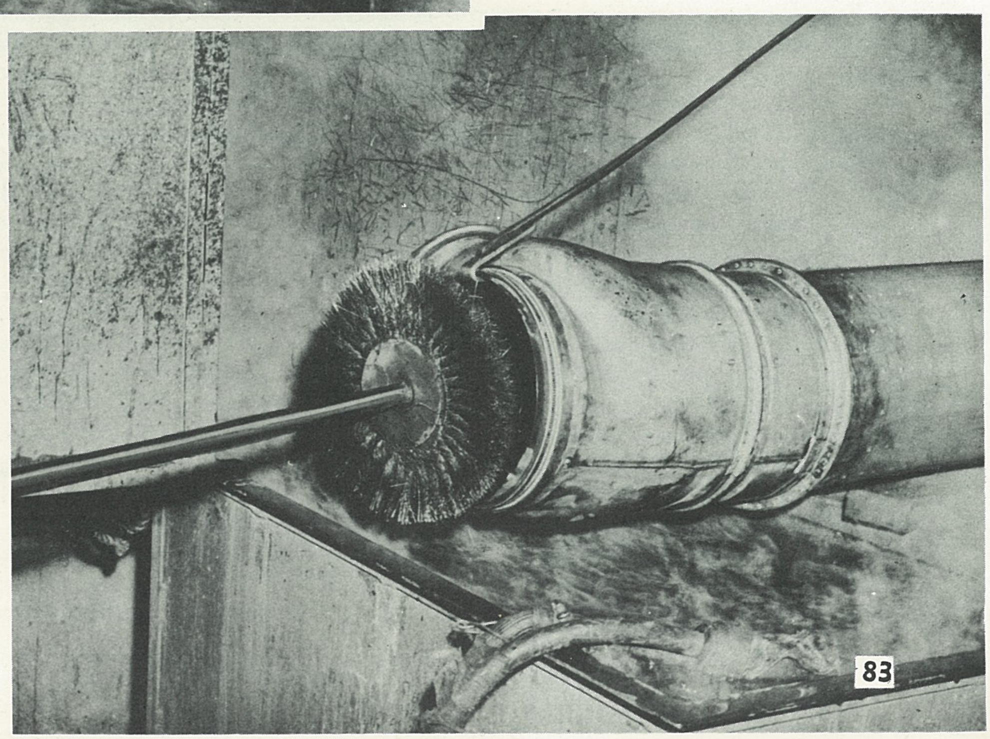
This same operator uses the cold-tank method of cleaning, using a solution of Turco 3310 (Transpo), which is a two-layer material that is used full strength. Transpo solution is neither heated nor air-agitated. The operating temperature is 85°F. The top layer (10%) is a floating seal which prevents escape of solvent vapors, and minimizes dragout, permitting the use of more potent cleaning solutions. The remaining 90% is a solvent that breaks up adhesion of hard carbons and soil, and penetrates to the metal, dissolving the bonding materials.

Augmentor tubes are immersed entirely in the solvent layer. The floating seal layer, which is approximately three inches deep, is not designed to perform a cleaning operation. Parts are racked so that they drain as completely as possible, thus reducing drag-out loss to a minimum. Tubes are soaked for a minimum of 48 hours in a rectangular tank that will accommodate six tubes. The soaking time is extended as time permits.

Many of the tubes cleaned in this manner are well into their second 3000-hour service period. The only repairs consist of replacement of the wear band at the forward end, and minor repairs to the outer shroud. Careful handling of the tube is emphasized during removal, cleaning, repair, and reinstallation procedures.



Tube is lifted from rinse tank and washed down with hot water. The gun has water and steam mixed under pressure.



Carbon on inside of tank which cannot be removed with steam-water is removed with a circular brush.

INSPECTION AND REPAIRS

It is difficult for Convair to formulate a definite augmentor tube inspection procedure or time interval because of varying conditions and operations. An inspection procedure that would prove adequate for one operator could conceivably be impractical for another. Inspection procedures and intervals can best be determined by the individual operator.

For those operators experiencing serious augmentor tube failures, Convair makes the following recommendations.

1. Visually inspect inner liner of augmentor tube at approximately every 100 hours. A flashlight beamed along the corrugations will reveal any sharp dents or cracks in the inner liner. Questionable conditions can be further inspected with a mirror. Severity of the crack or dent will dictate if outer shell inspection is necessary.
2. Remove blankets in wheel well area every 400 hours, and inspect the exposed portion of the tube. If there are any cracks, remove the tube and repair in accordance with instructions on page 88. Gradually extend 400-hour wheel well inspection as dictated by experience.
3. Wire-brush inside of tube at regular intervals. The individual operator is the best judge of how often the tubes need brushing.
4. Insure careful handling of tubes during installation, removal, and storage, to reduce possibility of dents in the outer shell.
5. Exercise care when working on top of nacelle. Do not kneel on augmentor tubes while working in this area.
6. Review cowl door and augmentor vane operating procedures.

Several operators believe that by removing augmentor tubes only at engine change much of the damage incurred in handling can be reduced. One operator states, "Our experience indicates that if you do not remove the augmentor tubes, you can lengthen the times between inspections and you add immeasurably to the overall life of the tube." This operator's records prove that the "leave them alone" policy pays dividends.

Another fallacy evidenced in frequent removals for inspection is that tubes may be removed unnecessarily for repair of minor cracks at spotwelds or doublers. The -260 tubes may show cracks at spotwelds on the aft portion of the muff and stiffening bands. Most of the cracks are small and show no tendency to progress. Removal of the tube to repair these small cracks, particularly those on flanges and beads, is believed to be unnecessary in view of the fact that none have been known to progress to a hazardous condition. Accordingly, cracks at the spotwelds that are 3/16 inch or less in length are not cause for removal.

Many augmentor tubes develop cracks in the outer shell, but these generally do not progress to a serious length except at the top of the tube. Six out of seven of one operator's full length failures were within one corrugation of the top; the other was in the bottom corrugation. The sequence leading to complete failure is first a crack in the shell, which progresses to a length assumed to be approximately 18 inches. This allows bending of the inner corrugated section and eventually results in cracking. From this point on, the rate of failure is progressively faster.

There is no correlation between the cracks and overheated tubes. One of the seven tubes was completely failed at 130 hours and showed no signs of heat; all others had a normal appearance.

Augmentor tubes that are found to be cracked in the corrugated inner liner are not considered to be airworthy. Repairs to this section of the tube are not considered feasible, and tubes should be scrapped.

All dents having sharp edges should be repaired by the addition of a patch. See View A. Any cracks exceeding ¾ inch in length may be repaired as shown in View B. If the inner corrugated liner is not damaged or warped and the outer shell has no more than three cracks less than ¾ inch in length, and no two cracks are within six inches of each other, the airplane may be flown to a base station for augmentor tube repair.

Minor cracks existing in wear bands, doublers, stiffeners, and flanges in the vicinity of spotwelds, which do not exceed ¼ inch in length and which show no signs of progressing, need no immediate corrective action and may be repaired at such time as complete overhaul of the tube is accomplished. Augmentor tubes having cracks in wear band doubler, at forward end of outer shell, are considered airworthy and no immediate corrective action is necessary until such time as complete overhaul of the augmentor tube is accomplished.

If the inner corrugated liner is not damaged or warped, and existing cracks are no more than ¾ inch in length, a temporary repair may be made as shown. Avoid this type of temporary repair in areas where it becomes necessary to wrap over a previous repair, because an adequate seal cannot be made.

Note

Temporary repairs should be limited to a maximum of eight flight hours before effecting a permanent repair.

Excessive wear of wear-band doubler at forward end of outer shell may be repaired by riveting and silver-soldering a band over the worn band or by replacing the worn band. Care must be exercised to locate rivets between the corrugations and to clear the area of contact with the spring clamp.

Cracks existing in the outer shell, including cracks along the seam weld at the lap of the outer shell and adjacent to the seam weld ending at the angle or doubler of the outer shell, may be repaired as shown. Repairs to the outer shell may be as numerous as required to any one augmentor tube, provided that the inner liner corrugation is not damaged or warped. Cracks not exceeding ¾ inch may be repaired by silver-soldering without patching.

Cross-weld cracks at the end of the seam weld may be repaired by silver soldering. To avoid warpage, apply sufficient flux to cover area approximately six inches square. Use minimum amount of heat. Use hand tools to smooth any wrinkles that may have resulted from soldering. Apply fillet of silver solder on each side of each corrugation to reinforce and reduce possibility of cracks developing at forward end of seam weld.

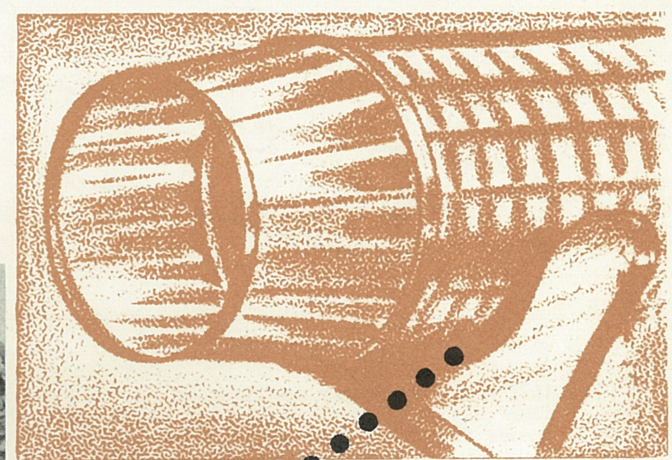
Cracks existing in heat takeoff muff may be repaired as shown in View C. Heat takeoff muff attachment to tail pipe in the earlier design of the augmentor tubes was accomplished by spot welding. Heat takeoff muffs of augmentors of later design were attached by means of riveting. Heat takeoff muffs having rivets installed may be removed during repair, if desired.

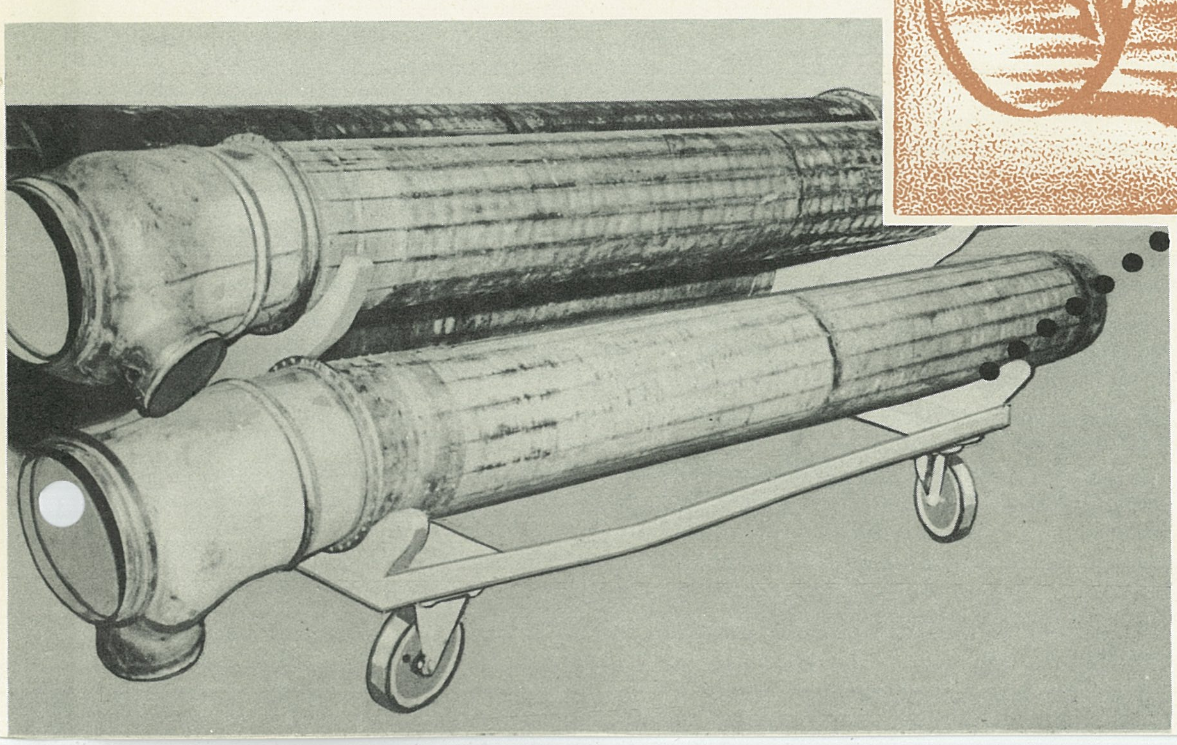
HANDLING AND INSTALLATION

The following recommendations are offered to minimize augmentor tube damage during handling and installation.

Store or transport augmentor tubes in suitable racks or in the original cartons to reduce the possibility of inflicting dents between the corrugations of the outer shell, or of damaging the heat takeoff muff. Some operators use specially constructed wheeled carts to facilitate handling of the tubes. Dents or damage incurred during handling result in cracking of the augmentor tube in service.

When installing the tubes, do not torque the forward support clamp beyond the recommended value of 20 to 30 inch-pounds. This permits the tube to





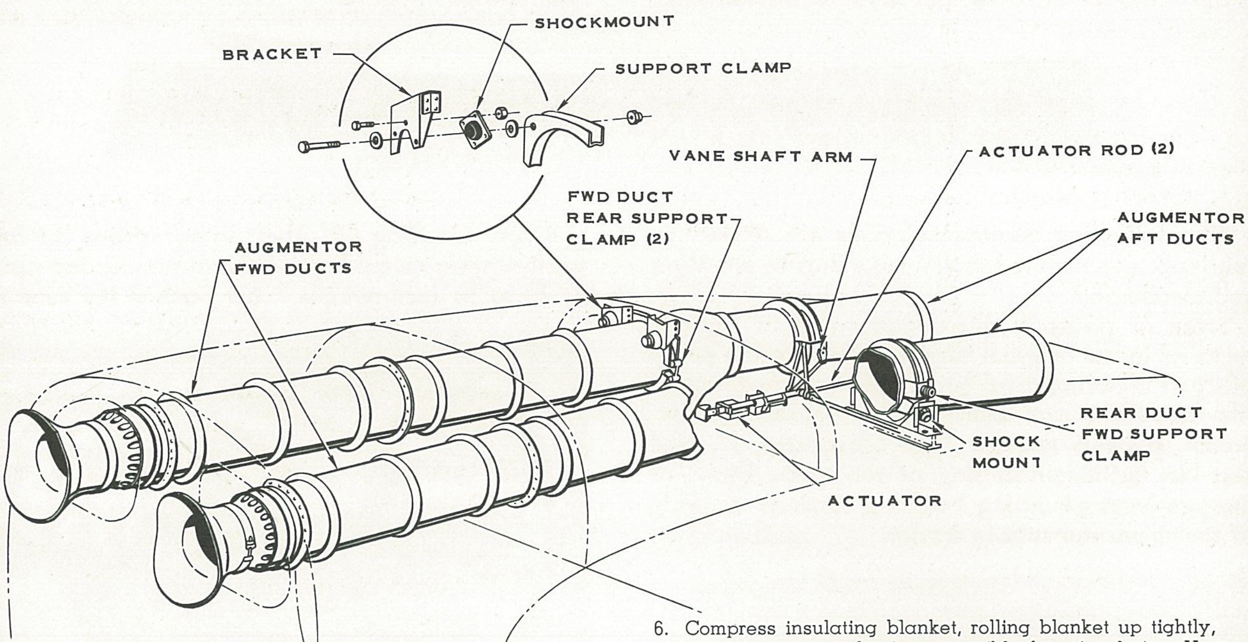
Wheeled rack which adequately supports augmentor tubes is recommended. Note felt pad which cushions tube during transportation.

expand forward. Do not preload the augmentor tubes in any manner during installation. A suggested procedure is to install the tube, and clamp it in position at the fire wall, leaving the rear spar attachment free. Install the tailpipe, bolt it to its mount, and then clamp it to the augmentor. If the lugs on the tube do not align with the holes in the rear spar mounts, replace the existing brackets with new undrilled brackets to obtain correct alignment.

Augmentor tube failures may also be caused by improperly rigged heat supply valves, in conjunction with overpriming during engine starting. A heat supply valve that is not adjusted to close completely will allow fuel vapor to be drawn into the augmentor tube between the corrugated inner liner and the outer shell and thus into the heat takeoff muff during starting, especially if the engine is overprimed. If these vapors are ignited, inward buckling of the tailpipe portion just aft of the corrugations may occur. These buckled spots soon crack out under normal heat and vibration.

The starter electrical circuit is designed to prevent starting the engines with the heat supply valves open; however, an improperly rigged valve will void this provision of the starter circuit. Exercising care during engine starting to reduce overpriming, and rechecking the rigging of the heat supply valves will prevent damage to augmentor tubes.

AUGMENTOR INSTALLATION



1. Install all blankets, except those in wheel well area, prior to duct installation.
2. Hoist outboard duct into position at aft end of nacelle. Slide duct (heat takeoff pointing up) forward until it passes through firewall opening. Make certain that heat takeoff is positioned so that it will clear rear shock mount beam.
3. Position heat takeoff opening downward to mate with heat exchanger outlets. Secure forward end of duct at firewall with seal ring.
4. Position bellmouth on duct; assemble clamp on flanged edges of both parts. Secure clamp, making sure that lips of clamp grip properly. Tighten clamp to a torque of 60 to 70 inch-pounds.
5. Install rear support clamp on forward duct and secure shock mounts, making sure that load side of forward shock mounts is aft.
6. Compress insulating blanket, rolling blanket up tightly, to remove as much air as possible from insulation. Unroll blanket; blanket may then be passed over and around forward outboard duct and secured by lacing hooks with safety wire.
7. Secure shock mounts and brackets to aft duct assembly prior to duct installation. Load side of aft shock mounts should be up.
8. Position outboard aft duct at rear of forward duct and secure ducts together with a clamp. Tighten to a torque of 60 to 70 inch-pounds.
9. Place aft duct supporting clamp in position and secure to duct. Secure shock mount bracket to support beam.
10. Install inboard forward duct and insulating blanket as outlined in steps 3 through 5.
11. Install inboard aft duct as outlined in steps 7 through 9.
12. Connect heat takeoff ducts to heat exchanger outlets.
13. Connect actuator rods to augmentor vane shaft arms.

CLEANING EQUIPMENT

Several operators have requested information on the establishment of cleaning equipment as well as for procedures for cleaning. Following are a few points to keep in mind when planning and installing tanks and equipment for cleaning augmentor tubes and all engine parts.

1. Tanks should be constructed of heavy-gage steel, welded together. They should be properly reinforced to prevent buckling.

2. At least two tanks are required: one for soaking and one for rinsing.

3. In addition to a large drain line at the bottom of the tank, the line should be provided with a nipple that extends above the drain opening to prevent sludge from flowing into the sewer when the tank is being drained. After removal of the sludge, the nipple may be removed and the tank flushed with water.

4. The fresh water line into the rinse tank should provide a constant flow of fresh water so that the rinse does not become contaminated. Rinse water should enter the tank through sprays or perforated tubing, on the side opposite from the overflow dam so that fresh water will force floating contaminants into the overflow. The sprays should have the nozzles so placed that water is directed in several directions. Water pressure should be sufficient to remove loosened deposits.

5. The overflow dam, opposite the fresh water lines, will keep surface of water free of oils and oily substances. The overflow lines should be at least twice as large as the fresh water lines to permit constant changing of rinse water in the tank.

6. A false bottom in the tank will assist in retrieving small articles when the tank is being used for cleaning engine parts. This false bottom may be constructed of fine grid, or may be a shallow pan.

7. The cleaning tank and rinse tank should be adjacent to each other so that parts can be removed from solution and immediately dipped into the rinse tank. Parts should be rinsed before solution has a chance to dry, because a delay in removing solutions may stain parts.

8. A thermometer should be so located as to give accurate temperature readings of the solutions.

9. Monorails, hoists, or similar lifting devices should be provided for lifting tubes or other heavy, bulky pieces of equipment, and for transferring them from one tank to another.

10. Immersion type heaters, thermostatically controlled, should be installed if hot-tank cleaning solutions are to be used.

11. From a safety standpoint, all controls should be located away from the tanks and should be easily accessible so that they can be operated during such emergencies as boil-over of solutions. A fresh water supply should be immediately available for emergency action.

12. Tanks should be located in well-ventilated areas where vapors and steam are quickly dissipated.

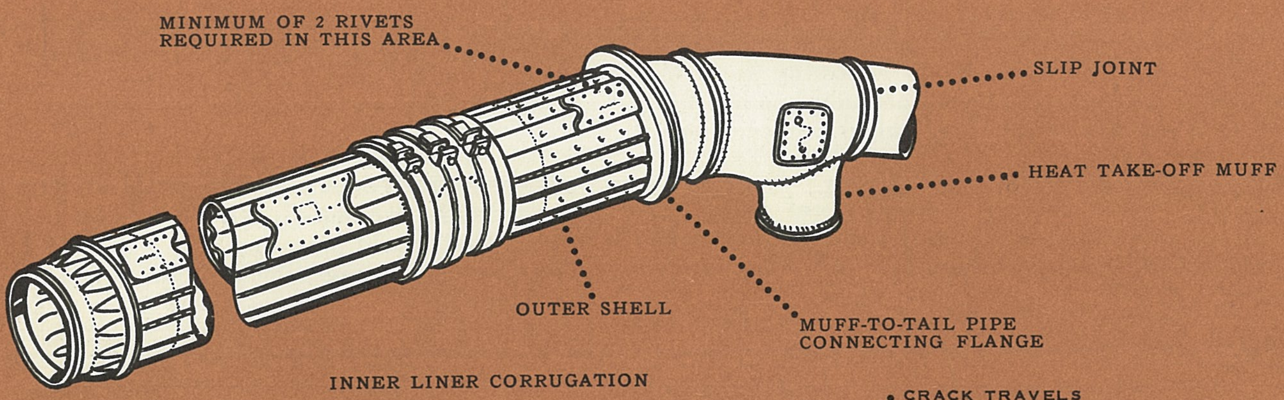
13. If tanks are recessed in floor, guard rails should be provided.

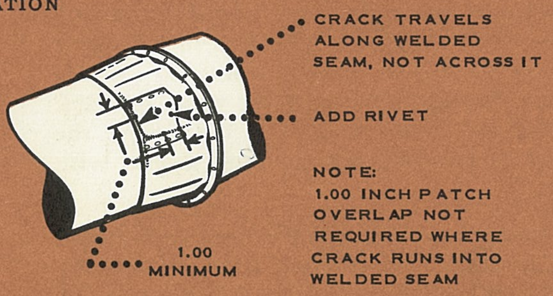
14. Precautionary placards should be posted in conspicuous places.

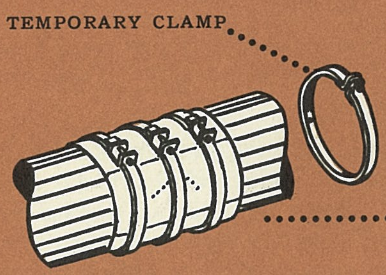
SUMMARY

Convair is entering into a service test program with United Air Lines to explore the service life of heavier gage tube materials. The following gages are to be used: .025 outer sheet; .030 transition sections; and .020 Stellite wear band, coated with Fel Pro C-5 compound, high temperature lubricant. Results of the service test program will be made known when information becomes available. Although improved service life is anticipated with the heavier gage tube assembly, Convair believes that attention to recommended handling, installation, cleaning, inspection, and operating procedures is of paramount importance with the existing tube and with the service test tube.

AUGMENTOR TUBE REPAIR







VIEW A — OUTER SHELL
TEMPORARY REPAIR

Using No. 30 (.128) drill, stop-drill cracks at each end.

Fabricate patch from .020 type 321 or 347 annealed stainless steel sheet. Patch must overlap a minimum of 6 inches and extend a minimum of 6 inches fore and aft of damaged area.

Hold patch in place with at least 3 clamps a maximum of 12 inches apart. Marmon strap clamps may be used, or clamps may be fabricated from .040 type 321 or 347 stainless steel sheet. Check clamps to insure patch is firmly in place and properly clamped.

VIEW B — OUTER SHELL
PERMANENT REPAIR

Cracks ¾ inch and under may be repaired by silver-soldering; no patch is required. For larger cracks, use No. 30 (.128) drill to stop-drill cracks at each end through outer shell only. Exercise care to avoid drilling into inner liner.

If two cracks exist in same corrugation, trim away areas of outer shell which are cracked loose, and radius ends of cutouts.

Fabricate patch from .020 Type 321 or 347 stainless steel sheet. Patch must extend a minimum of 2 inches fore and aft of crack and tangent to adjacent seam welds. Cracks adjacent to seam weld ending at angle or doubler, forward or aft of augmentor tubes, may be repaired as shown, except that patch must be cut square at one end and joggled to fit angle or doubler.

Install CR563-4-2 rivets. Space, as required, to prevent edge of patch from showing between rivets. A minimum of 2 rivets is required at ends of patches ending at angle or doubler.

Silver-solder around edges of patch. Apply silver solder to Cherry rivet plugs to prevent stems from working out.

VIEW C — HEAT TAKE-OFF MUFF
PERMANENT REPAIR

Using No. 30 (.128) drill, stop-drill crack at each end. Trim away loose material as required.

Fabricate patch from .020 type 321 or 347 annealed stainless steel sheet. Extend patch one inch beyond limits of crack. Pre-form patch before installing.

Install CR563-4-2 rivets, and space as required to prevent edge of patch from bowing between rivets.

Silver-solder around edges of patch. Apply silver-solder to Cherry rivet plugs to prevent stems from working out.

Note: Clamp patches tightly in place before riveting or silver-soldering so as to assure close contact with areas being repaired.

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NUMBER 8

FOREWORD

The successful removal of snow and ice from an airplane is dependent on the knowledge and assistance of ground crews and on their familiarity with weather conditions and effects. Because these factors are so well outlined in an article titled, "Take it off . . . and Keep it off," in Aircraft Accident and Maintenance REVIEW, USAF publication, we obtained permission from the editors to republish a large portion of the material in the Traveler. We've revised the article as necessary to make it applicable to Convair-Liner aircraft, and have added some procedures and cautionary measures that are peculiar to Convair-Liner operation.

ON THE COVER

The snow bird on the cover may appear to have time on his hands but he's just posing for Willis Goldsmith's sketch. His activities throughout this issue show how energetic he really is.

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R. L. Bayless

Chief of Service
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A digest of Convair-Liner operation and service published monthly by the Service Publications Section of Convair in the interest of Convair-Liner operators. Communications should be addressed to Chief of Service, Convair, San Diego 12, Calif.

CONVAIR
A DIVISION OF GENERAL DYNAMICS CORPORATION
(SAN DIEGO)

COLD WEATHER OPERATION
240 - 340 Airplanes

attention: ground crews

Convair is grateful to the editors of Aircraft Accident and Maintenance Review for granting permission to publish information on cold weather operation, which appeared in the October 1955 issue of Review. The article has been changed only as necessary to make it applicable to Convair-Liner aircraft.

Of great concern to an aircraft operator is the dispatching of aircraft within the time limits established by him. Meeting these schedules often becomes difficult during winter operation due to snow and ice accretions on the airplane while it is on the ground. These accretions must be removed before takeoff because such formations may interfere with the controls systems and may decrease performance.

The flight characteristics of an airplane carrying snow or ice are similar to those of an overloaded airplane. Even a thin layer of snow or frost may cause loss of lift, and adversely affect stall characteristics. Frost, frozen snow, or any deposit which presents a rough or uneven surface gives the greatest amount of trouble because of its effect on the airflow. This is particularly true if these deposits are located on the upper surface of the wing between the leading edge and the 15 per cent chord point.

Deposits have the greatest effect at low speeds and high angles of attack such as occur during takeoff and climb. The danger is mainly due to an increase in stalling speed, approaching or even exceeding the normal expected takeoff speed. An added danger is generally less effective control, because of interference with smooth airflow over the control surfaces.

The effect on control is very difficult to predict. Deposits located back of the critical lift portion of the wing may have serious effects upon the control surfaces. Isolated deposits, seemingly unimportant, may blank out a control surface or reduce its effectiveness. The lower surface of the horizontal stabilizer is about as critical as the top. Here, mud is often a serious offender.

Many pilots feel that deposits on the tail are more serious than on the wing, due to the effect on control. Deposits of frost or freezing rain may accumulate on one side more than the other and induce a turning effect on takeoff. The space between fixed and movable surfaces should be free of deposits which might cause binding. This is especially true for balance compartments. This chamber, provided for the balance arm of the control surface is very critical to deposits, and should be thoroughly checked.

Propellers are extremely critical to ice and no amount should be allowed to remain under any circumstances. Ice accumulations during ground operation may break away and damage the fuselage forward of the ice protection shields.

If high relative humidity and freezing temperatures exist, anti-icing systems should be operated immediately after starting engines and during warmup, taxi and takeoff, and in flight whenever visible moisture exists or icing is suspected.

The fuselage, except at the wing and tail juncture, is less critical to deposits and normally is not de-iced unless the deposit is unusually thick and would add considerable weight and drag. Where range is critical, all fuselage deposits should be removed. If the fuselage or windshield is de-iced with chemicals, care should be taken to remove all slush formed ahead of the windshield, since it may blow back during takeoff and obscure vision.

Nacelle deposits may create aerodynamic interference with airflow over the wing. Also, melted deposits may refreeze on cowl flaps or wing flaps and prevent proper operation. Dry snow may sift into nacelles and wheel wells, thaw and refreeze, causing propeller or engine controls to bind.

Air inlets and vents should be thoroughly inspected for ice and, if necessary, de-iced with an alcohol-type de-icing fluid which will combine with any remaining water. This will prevent freezing.

The static pressure source for flight instruments is located on the fuselage flush with the skin. On Convair-Liners, icing protection is not provided for the normal static source, but system operation is assured through installation of the alternate static source, which is not affected by ice accumulation.

Pitot tubes should be cleaned of all deposits. Pitot heaters may be checked before takeoff by turning the heater on and noting a drop on the loadmeter. Heaters should not be left on for more than 30 seconds during ground operations, or the element may burn out.

Antennas should be thoroughly cleaned of deposits to assure proper radio transmission and reception.

The removal of deposits from critical surfaces should be complete. Broken or irregular pieces of ice remaining may create a greater disturbance than the original deposit. A good example of this is ice runback after heat anti-icing is used on the ground, with insufficient slipstream to remove broken pieces. The best policy is to remove *all* deposits from top and bottom of wing and tail surfaces and, if facilities and time permit, from the fuselage as well. Dry snow should not be left to blow off during takeoff run. Experience shows that dry snow tends to cling to airfoils. Usually this will prevent a successful takeoff.

Under conditions which make flight absolutely necessary without complete removal of deposits, at least those on the more critical portions must be removed and the aircraft allowed as long a ground run as possible to pick up extra flying speed before takeoff.

The person or persons responsible for prevention or removal of snow, frost, or ice deposits will, of course, depend upon the organization concerned. What is important is that the responsibility be clearly defined and known by all concerned, so that decisions can be made and action taken to prevent or eliminate deposits in sufficient time to avoid delay or cancellation of a scheduled flight. *Remember, properly planned prevention is easier than removal!*

There are many conditions which enter into the problem of prevention or removal of ice, snow, or frost deposits from aircraft. Those who must cope with the problem should be thoroughly familiar with all aspects of these conditions in order to aid them in making the proper decision as the occasion demands. Some of these conditions are as follows:

The present or anticipated air and airplane temperature.

The moisture content of the air.

The amount and type of precipitation occurring or anticipated.

The availability of hangar space.

The length of time an airplane will be unprotected.

The availability of de-icing equipment or protective covers.

Care must be taken when removing an airplane from a warm hangar. Dry snow falling on a warm airplane will melt and refreeze. If it is snowing it will be necessary to install protective covers; coat the surfaces with an anti-icing fluid; or open hangar doors and allow airplane to cool to the outside air temperature.

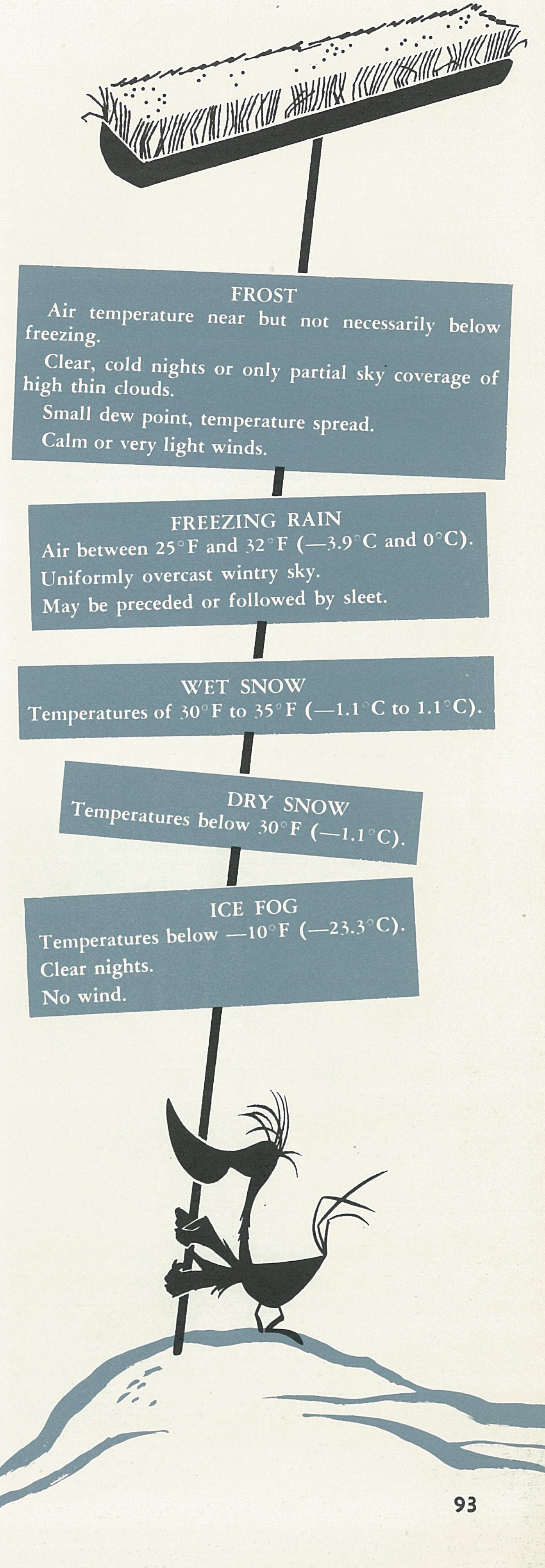
Covers in good condition are the best means of protection; however, their use is limited to smaller aircraft generally. A newly-designed net is expected to solve many of the problems involving larger aircraft. These nets, which may be in use at some facilities this year, are made from 1½-inch cotton webbing, constructed with three-inch square openings. Tests completed last winter showed that these nets removed approximately 90 per cent of a wet snowfall and 60 per cent of a dry snowfall. These tests were conducted on C-119 and KC-97 aircraft.

Convair has available covers for the following installations on Convair-Liner 240 and 340 aircraft: windshield, nacelle, propeller blades, and pitot tubes.

Covers should be used whenever an airplane is parked for one-half day or more at below-freezing temperatures and if a danger of precipitation exists. Caution should be exercised when using covers at temperatures above 25°F (—3.9°C). Freezing rain or wet snow may freeze covers to surfaces. Waterproof covers are less likely to freeze on the surface, except around the edges. A film of de-icing fluid should be applied before covers are installed. This will prevent them from freezing to aircraft surfaces. In no case should covers be installed over a surface with frozen or unfrozen moisture present.

Covers should always be dried after using. They must never be applied wet, since freezing to surfaces can occur, or shrinkage might injure control surfaces. They can be dried by spreading out on the hangar floor, or by draping over ropes hung in the hangar. If absolutely necessary to re-use covers without thawing out and drying, brush off any ice or snow deposit and store in a cold place until ready for use. They should be cleaned periodically to prevent oil, grease, or de-icing fluid from accumulating and rotting fabric.

The services of a weather man should be used whenever possible to forecast ice, frost, or snow, so that precautionary measures may be taken. The basic information here presented is to acquaint maintenance men with weather conditions which lead to formation of the following:



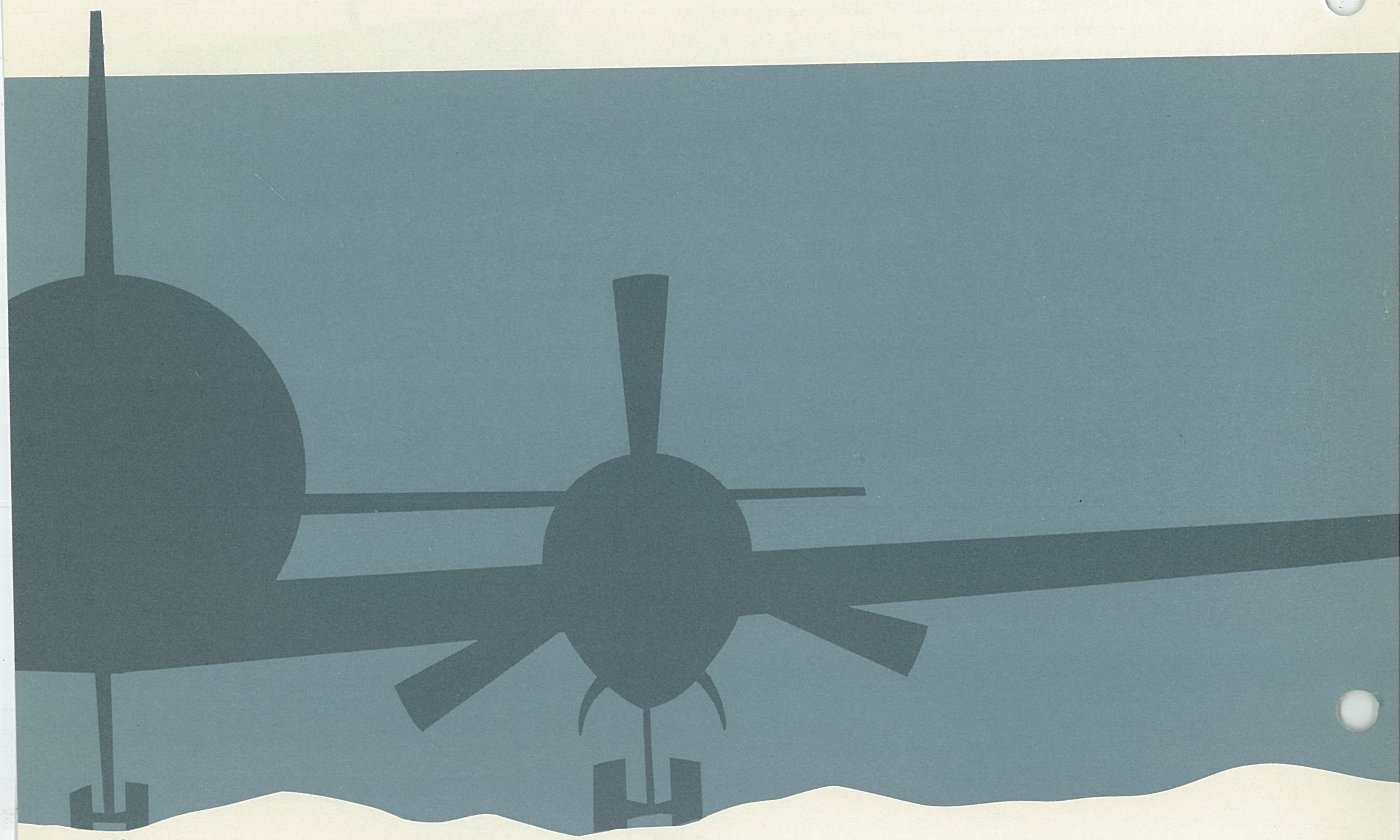
A protective coating of unheated, undiluted Defrosting and De-Icing Fluid will prevent frozen accumulations from forming on surfaces if applied before such conditions begin and if applied as often as necessary during the precipitation.

If the various prevention methods are not available, or an unforeseen storm catches the base with its covers down, the job of de-icing and snow removal takes the spotlight. Heavy snow should be swept off to check to see if ice is present. Oftentimes a dry, powdery snow will not have ice underneath, but a careful examination always should be made.

Chemical de-icing is an efficient method for removing frost or light ice deposits from surfaces. This method also may be used on heavy ice, but it takes considerable time and requires large quantities of fluid. However, if a heated hangar is not available, chemical methods must be used to remove ice which cannot be cracked with a soft rubber hose. Metal tools should not be used because their use may damage surfaces.

De-icing chemicals are most effective on frost and thin (less than 1/8 inch) layers of ice. Chemicals melt and loosen ice which is then easily brushed off. For rapid and economical removal of heavy deposits of frost or ice, a solution of water and ethylene glycol, which tests to 20°F (—6.7°C) below the ambient temperature, heated to between 180-200°F (82.2°C-93.3°C) should be used whenever practical. In either case, a final application of unheated de-icing fluid should be applied to prevent further deposits from forming.

When you are spraying with inflammable fluid, both aircraft and spray nozzle should be grounded to prevent static electricity from igniting vapors. De-icing fluids are relatively expensive and should be used carefully. It must be remembered that as the fluid acts on the deposit, it will become more and more diluted until it is no longer effective. At this point, the slush formed may refreeze, resulting in a surface rougher than the original deposit. It is important, therefore, that no melted deposits be allowed to remain on the airplane.



Any spraying device available can be utilized to apply chemical de-icing fluids. The effectiveness will vary depending upon the pressure available, the type of nozzles used, the amount of fluid sprayed in a unit time, and the ability to reach all parts of the aircraft. Requirements, too, will vary depending upon the size of the aircraft and amount of ice.

The Air Force MB-3 De-Icing Spray Outfit was designed specifically to de-ice large aircraft such as the B-36. The unit is mounted on a truck for mobility. It has two 500-gallon tanks, a 20-gallon per minute fluid pump driven by an auxiliary engine, and an articulated boom to lift the spray operator to any part of the airplane. The boom is mounted on a turntable driven by a hydraulic motor. The spray operator, standing on a self-leveling platform at the end of the boom, can manipulate the boom by hydraulic controls, allowing him to reach any part of the largest present day aircraft. He can attain a maximum height of 50 feet, or he can lower the upper boom to extend out over the surface he is working on. From this position he can rotate through 360 degrees by means of the turntable. Ground outriggers on the truck are provided to stabilize the unit. The spray nozzle is adjustable to provide either a fine spray or a high pressure stream.

At present, WADC has established a requirement for a fluid heater into the specifications for the MB-3 unit. This came as the result of exhaustive tests made last year at such frigid spots as Loring AFB, Maine; Goose Bay, Labrador, and Larson AFB, Washington. At Larson, two C-124's were cleared of heavy frost accumulations in one hour and 15 minutes using the heated fluid. At Goose Bay, seven KC-97's were cleared of two inches of ice and snow in 10 hours.

Standard decontamination trucks have been modified for de-icing. This unit consists of a truck with a fluid tank and spraying apparatus mounted on the chassis, modified by a B-1 hydraulic lift maintenance stand to provide a working platform for spraying. The stand raises from 11 to 18 feet, which is adequate for the operator to spray, though perhaps not to see, the topside of the surfaces of a B-36. Steam or vapor pressure steamers can be used to heat the solution of water and ethylene glycol. This unit is capable of spraying a considerable amount of fluid in a short time, and is very effective. As modified, this unit is recommended as the best present standard equipment adaptable for de-icing large aircraft.

The chart on this page was prepared by WADC, and was taken from WADC Technical Report 53-217, Part 3. It contains some good tips for maintenance personnel in an easy-to-read form.

And speaking of good tips, here are a few regarding organization, taken from the publication. They are applicable to airline operations.

DE-ICING CHEMICALS

1. AF Spec. 3609
2. Ethylene Glycol & water (3 to 1)
3. Lithium Chloride Solution
4. Methyl Alcohol*
5. Ethyl Alcohol*
6. Iso Propyl Alcohol*

*Use only when other chemicals are not available.

REMOVAL OF FROST, ICE OR SNOW FROM PARKED AIRCRAFT

CHECK POINTS

1. Top and bottom of all flight surfaces
2. Air intakes and vents
3. Control surface gaps
4. Hinge points
5. All movable parts
6. Antennas and radar enclosures
7. Windshields and adjoining areas

Deposit	Dry Snow	Wet Snow	Frozen Snow	Ice	Frost
Weather	1. Overcast skies. 2. Temperature below 30°F.	1. Overcast skies. 2. Temperature 30-35°F.	1. Temperature drop after wet snowfall.	1. Uniformly overcast skies. 2. Temperature 25-32°F.	1. Temperature near freezing. 2. Clear skies—night. 3. High relative humidity. 4. Little or no wind.
Prevention	1. Protective covers. 2. Frequent removal of snow prevents packing.	1. Waterproof protective covers. 2. Frequent removal more important.	1. Do not allow wet or dry snow to remain on surface, and thaw and refreeze. 2. Do not remove aircraft from hangar during snowfall.	1. Frequent application of de-icing fluid may prevent freezing. 2. Remove water or slush that may freeze.	1. Protective covers. 2. Application of de-icing fluid (temporary protection only).
Removal	1. Sweeping. 2. Cloth Strip. 3. Ground run.	1. Sweeping. 2. Mopping. 3. Cloth Strip.	1. Sweep to remove loose deposits. 2. Apply chemicals by mop or spray. 3. Use heat under cover as alternative method.	1. Allow ice to melt off in hangar. 2. Beat off with short rubber hose. 3. Apply chemicals generously. 4. Use heat under cover.	1. Chemicals, mop or spray. 2. Cloth strip. 3. Place aircraft in bright sun.
Cautions	1. Chemicals are wasteful in removing dry snow. 2. Check all air intakes and openings for blown snow.	1. Check all openings, moving parts, etc. where snow may collect and freeze. 2. Dry surface after removal of snow. 3. Check for frozen slush on underside of surfaces.	1. Check surfaces for frozen snow after wet or dry snow has been removed. 2. Do not heat surfaces over 160°F.	1. Check all openings and movable parts. 2. Check for run off water that has frozen between or on underside of surfaces. 3. Take care to avoid damage to surfaces when beating.	1. Do not underestimate effect of frost. Remove from top and bottom of all flight surfaces and antennas.

"The responsibility for the actual prevention or elimination of ice, frost, or snow deposits usually lies with the maintenance section of an organization, which will, of course, be alert to seasonal demands. The beginning and end of the icing season is usually most critical when temperatures hover around freezing and humidities are relatively high.

"Freezing rain, the most difficult deposit of all, is apt to occur, and frost is generally found covering all parts of the airplane each morning. During the colder months, precipitation in the form of dry snow is easy to remove. The absolute humidity is so low at low temperatures that heavy frost rarely occurs. Ice fog is sometimes a problem, but generally only in the Arctic.

"To provide a deadline for preparations, it is wise to set a date after which all precautions will be taken to prevent deposits from adhering to aircraft. At least one set of wing and tail covers should be on hand for each aircraft for which covers are practical. They should be clean, all tears repaired, and quick release fasteners in workable condition. Engine nacelle disks or covers and inlet duct dust and snow excluders should be inspected and repaired when necessary.

"A sufficient stock of de-icing fluid should be on hand at base and organization levels to cover anticipated requirements. An adequate reserve should be allowed for unusually severe conditions.

"At least one large spray apparatus, such as the MB-3 or modified decontamination unit, or their equivalent, should be located at each base where the de-icing problem exists. A second unit capable of large scale spraying should be on hand in case of failure of the primary unit and to aid during peak periods. In addition, each organization should have individual means, independent of the base unit, of accomplishing spraying. A good supply of mops, push brooms, and hand pump sprayers should be available also. A rack for storing dry covers is desirable to keep covers off the floor and in one place for ready use. Some means for drying covers is an absolute necessity.

"It is best to have a written SOP (Standard Operating Procedure) to be followed during the icing season—not only for de-icing but for winter operation in general. The following points are pertinent to a de-icing SOP:

Inclusive dates during which anti-icing precautions will be observed regardless of forecast conditions.

A statement regarding the necessity for complete elimination of all deposits from critical parts of the airplane prior to takeoff.

The precise responsibility of organizations and individuals for prevention or elimination of deposits and care and operation of equipment.

Reference to technical orders outlining procedures for de-icing.

Special procedures or precautions which are necessary for the type aircraft or equipment assigned.

Special dispatching procedures and earlier crew reporting times during the icing season to allow for the greater time required to prepare aircraft for flight."

PROCEDURES TYPICAL TO CONVAIR-LINERS

The following precautionary measures are necessary for satisfactory operation of Convair-Liner aircraft during cold weather.

1. To eliminate freezing of controls during winter operation, keep all areas well-drained. When washing down the airplane, avoid excessive accumulations of water in the nacelle area. Water that remains may freeze and lock engine controls. A light coating of oil on external servicing fittings is beneficial in preventing formations of ice.

2. If airplane is to be parked outside without heat, drain lavatory water tanks and drinking water bottles in accordance with the following table:

O.A.T.	DRAIN
—32°F (—35.6°C)	Immediately
25°F (—3.9°C)	Within 2 hours
10°F (—12.2°C)	Within 1 hour

Drain ADI tank in accordance with the following table.

O.A.T.	MIXTURE
—45°F (—42.8°C)	50% methyl alcohol 50% water
—32°F (—35.6°C)	25% methyl alcohol 25% ethyl alcohol 50% water
—55°F (—48.4°C)	60% denatured Methanol 40% water

3. Drain fuel sump (accessible through each MLG wheel well) and main tank sump drain (accessible through doors on outboard side of each nacelle).

4. Drain pitot-static lines. The pitot water drains are located in the nose wheel well, one on each side. There is also a small hole in the lower side of each pitot tube. Check to see that these holes are unobstructed by ice. Static drains on the Convair 340 are accessible through a small door in the stress panel aft of the NLG doors on the bottom of the fuselage. Drains are located under the top step of the main entrance door ramp on all Convair 240's except on those that have the rear entrance ramp. In these airplanes, the drains are located in the forward section of the lower cargo compartment.

5. Drain rudder torque tube at each preflight when operating in wet weather and after each washdown to preclude the possibility of freezing. The drain cap at the base of the tube is accessible through a small door in the rear of the cargo compartment. On Convair-Liner 240's with the rear entrance ramp, access is through the zippered opening in the coat compartment on the left-hand side of the airplane.

6. If the airplane is to be parked for long periods of time, leave pilots' sliding windows partially open to permit circulation of air inside the airplane and thus prevent frosting of windows.

7. Do not set parking brakes because ice formed by condensation may freeze them in the applied position. Use sand bags or wheel chocks. Chocks should not come in direct contact with tires. If brakes freeze, thaw and dry with ground heater.

8. If possible, park airplane in an area that is clear of snow and ice, or park with wheels on heavy wrapping paper or sand. If tires freeze onto snow or ice, do not move airplane until tires are freed. This can be done by use of rock salt or by applying heat to the area.

9. In preparation for flight, preheat cabin with a ground heater attachment, the period of preheating depending upon the temperature and on the period of time the airplane has been without heat.

10. Prior to takeoff, check for free movement of all controls through full range of travel. If forces necessary to operate are excessive, check all exposed hinges for presence of ice or frozen accumulations and remove.

11. Prior to taxiing and towing, slowly depress brake pedals several times. Apply and release parking brake to insure unrestricted operation.

12. Slush splashed on wing center section and wing/fuselage fillet during taxiing and takeoff roll, will freeze and cause a buzz condition that should not be mistaken for pre-stall buffeting. Such ice cannot usually be removed in flight; however, lowering the wing flaps a few degrees will normally deflect the ice-induced turbulence from the elevator control surfaces.

13. After landing, to obtain sufficient dilution of oil to facilitate restarting, engines should be allowed to cool by idling at 1200 rpm for a sufficient time to reduce cylinder head temperatures to a maximum of 148°C, and allow oil temperatures to drop to 30°C to 40°C. These temperatures usually will be obtained during the time the airplane is being taxied to the line. It may be necessary, however, to shut down the engine for a period of as much as one-half hour to allow oil temperatures to reach the desired level.

The following table shows the recommended dilution intervals for Convair-Liners at expected temperature ranges:

O.A.T. (Anticipated)	DESIRED DILUTION		DILUTE INTERVAL		SERVICE TANKS (gals.)	
	240	340	240	340	240	340
39 to +10°F (4° to —12°C)	10%	10%	2 mins.	4 mins.	*18 17	26
+10 to —20°F (—12 to —20°C)	20%	20%	4 mins.	8 mins.	*15.5 13.5	21.5
Below 20°F (—29°C)	30%	30%	6 mins.	12 mins.	*13 10	17

*With hoppers

Note: For Convair 240's with Curtiss Electric propellers and no oil hoppers, service tanks to 19, 15.5, and 12 gallons, respectively.

If it is necessary to service the oil tank it should be done prior to dilution.

Under extreme weather conditions (below 0°F or —17.8°C), dilute oil in the propeller feathering line by exercising the propeller control during the latter part of the dilution interval. The engine should be brought up to 1500 or 1600 rpm momentarily so that the governor will operate.

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FOREWORD

Weather plays an important part in airline operation because regularly scheduled flights are a must for public acceptance of air transportation. Many navigational and landing aids have been devised to improve the safety and reliability of air transportation. The newest of these is airborne weather mapping radar with which the pilot can select a corridor of minor turbulence through areas of thunderstorms, damaging hail, and heavy precipitation.

Without airborne weather mapping radar, the pilot must draw on his knowledge of the structure of cumulous clouds and avoid the areas where trouble-making clouds exist.

In this issue, we have attempted to familiarize the pilot with the more important aspects of weather analyses in general, and to acquaint him with the causes and effects of weather phenomena as they apply to him in particular in the safe flight of his aircraft.

Chief Engineer
R. L. Bayless

Chief of Service
J. J. Alkazin

Editor
G. S. Hunter

ON THE COVER

The weather bird is prepared for any weather that may be expected along a proposed route. With his weather eye he has successfully assisted the pilot in guiding the airplane through areas of least turbulence.

The artist: Willis Goldsmith

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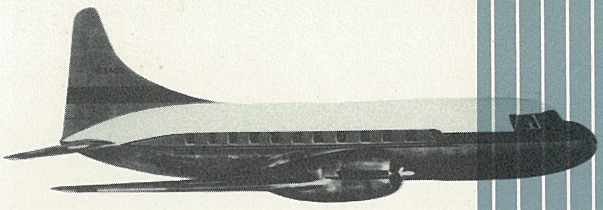


WEATHER OR NOT

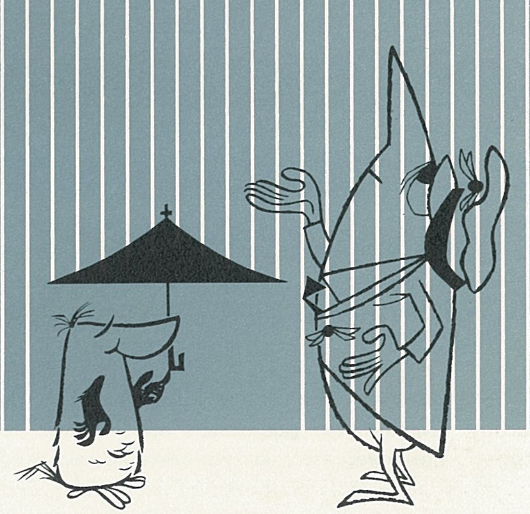
"Everyone talks about the weather, but no one ever does anything about it," isn't entirely a true statement. Weather is of great concern to the pilot and, although he can't change it, he can in many cases avoid it and/or fly his airplane accordingly. He can't rely on old folks' tales or homespun methods of making predictions. He, like the weatherman, must depend primarily on barometric pressure, because he knows that changes in barometric pressure mean changes in weather.

Flight in turbulent air is the most frequent weather problem encountered by flight crews. The most severe turbulence, caused by temperature and pressure changes, results in thunderstorms, tornadoes, hail, ice, or any number of weather phenomena.

To assist pilots in avoiding heavy turbulence, some operators have installed airborne weather mapping radar. With this device, the pilot can detour hail and heavy precipitation with minimum deviation from the flight plan. Without airborne weather mapping radar, the pilot must rely on ground radar stations and visual reference to cloud formations. Ground station radar can assist the pilot in making a flight plan from existing weather conditions in the surrounding area, but its usefulness decreases as the airplane moves out of the radar area. Too, the conditions noted during preparation of the flight plan may change rapidly with the fast-changing cloud formations.

Clouds are weather telegrams hiding accumulations of water and snow, and transmitting their messages to anybody who knows how to read the signs. The pilot's knowledge of clouds helps him to predict the weather and to select a flight path of least turbulence. Although clouds are an important guide to weather, most rules concerning them can vary just as the clouds vary as they sweep across the sky.

All clouds, even the fair-weather cumulus and cirrus, contain water and ice crystals. The movement of air currents within a cloud stir up these crystals and amass them into larger crystals. When they become heavy they fall to the earth either as snow or rain, depending upon the temperature of the layers of air through which they pass. If they pass through air layers that have freezing temperatures, they may fall to earth as snow or hail; if they pass through air that is warmer than freezing, they melt and fall to the earth as rain.



Whether flight is made in actual thunderstorm weather or in clear air, turbulence and the hazards that accompany it may be encountered, so the pilot must always be defensively alert to avoid the hazards created by weather. How to cope with the problems associated with turbulent flight is discussed on the following pages.

FLIGHT IN TURBULENCE

Flight in turbulence, which presents several difficult problems to the pilot, is most preferably resolved by following two simple rules:

1. Maintain a predetermined turbulent air penetration speed, and

2. Maintain the proper aircraft attitude, to prevent stalling.

A single turbulent-air penetration speed has been determined as most desirable for each type of transport aircraft. In the selection of this airspeed, consideration is given to structural integrity, gust intensity, aircraft gross weight, aircraft handling, and the normal altitude operating range of the aircraft. No consideration is given to cruise control or fuel conservation in the determination of this airspeed.

Structural Integrity can be compromised most readily by an undesirable combination of over-controlling (maneuver loads) and severe turbulence (gust loads). Generally speaking, the higher the airspeed when the aircraft is displaced from its flight path, the greater are the loads to recover. Conversely, very low airspeeds invite delayed response and over-controlling, which makes the maintaining of aircraft control even more difficult. The optimum in a desired airspeed will then be one that is sufficiently high to allow good aircraft handling, but low enough to prevent the introduction of excessive loads that might contribute to structural failure.

Modern structural design of aircraft provides sufficient strength to safely sustain a load 50 per cent greater than the limit load specified. Pilots can further protect the aircraft from structural overloads by flight at airspeeds commensurate with the degree of turbulence encountered. Airspeed, however, can be reduced to a point at which a severe gust will cause a stall, before load limits are exceeded. If extreme turbulence causes a pilot to lose control momentarily, the safe limit speeds in a resultant dive are higher with the flaps retracted.

Gust Intensity is completely a function of the prevailing atmospheric conditions and cannot be controlled. However, aircraft accelerations sustained from the gusts are directly proportional to the airspeed. This consideration then, would warrant a slow airspeed.

Civil Air Regulations define the manner in which the design speed for maximum gust intensity (V_b) and maneuvering speed (V_a) shall be determined for Transport Category aircraft.

"V_b shall be the speed at which the 40 feet per second gust line intersects the positive C_n maximum curve on the gust V_n envelope." See Figure 1.

"The design maneuvering speed (V_a) shall be equal to $V_{s_1} \sqrt{N}$ where N is the limit maneuvering load factor used, and V_{s_1} is the stalling speed with flaps retracted at the design takeoff weight." See Figure 2.

Aircraft Gross Weight is indirectly concerned in considering this problem since, generally speaking, nothing can be done to alter it in the event turbulence is encountered. It has, however, a definite and important effect on selection of the proper airspeed.

Aircraft Handling. It is well known that instrument flight at the higher airspeeds requires a greater degree of pilot skill and increased concentration. It is also well known that the effects of gust accelerations are greater at these higher airspeeds.

A combination of the two forementioned conditions produces an aircraft handling problem that can best be relieved by utilizing a reduced airspeed that is simultaneously high enough to provide good flight handling characteristics.

Normal Altitude Operating Range requires consideration of gust intensity, structural integrity, and aircraft handling problems. The operating range between stall and maximum airspeed (or buffet) decreases appreciably with altitude.

It should be noted that in none of the forementioned problems is a high airspeed listed as being the best solution for flight in turbulence. It would then seem logical to utilize a satisfactory lower airspeed. The lowest possible airspeed would, of course, be slightly above the stalling speed. However, since the stalling speed is affected by gross weight, aircraft configuration and acceleration, it may prove more desirable to specify a penetration speed in relation to the variable stall speed, rather than a fixed number (V_b) as a penetration airspeed. As an example, an airspeed of 60 knots above the power-on stall speed has been analyzed for Transport Category aircraft. This airspeed approximates the

final approach airspeed for these aircraft, with a 10 per cent safety factor added.

In this category of aircraft, such an airspeed is sufficiently low to prevent structural damage during severe gusts. In addition, there is considerable margin between the specified limit load and the ultimate load where structural failure will occur. Loads in the latter range are the result of attempted recoveries from over-controlled maneuvers, rather than from gusts.

Since such a penetration speed is in direct proportion to stall speed, and since the stall speed will vary with aircraft gross weight, Center of Gravity location, and aircraft configuration, these items are automatically compensated for.

In the comparatively low-speed range utilized in the foregoing example, gust accelerations are minimized and the most comfortable ride is provided. Because of this low airspeed, however, the question of stalling possibilities should be clarified.

To this point, all of our discussion has been based on the effects of a single gust, in fact, on a theoretical sharp-edge gust. In reality, the possibility of a single gust causing an aircraft to stall is remote. Studies have indicated that the average distance an aircraft will cover while reaching peak acceleration in a gust is approximately 10 wing chord lengths. Using the 9½ feet M.A.C. of the 340, approximately 95 feet will be covered in reaching the maximum acceleration. Utilizing the suggested formula of "stalling speed plus 60 knots," and a conservative 340 stall speed of 90 knots, the aircraft would be flying at 150 knots or approximately 250 feet per second. In this typical example, the aircraft would completely transverse the gust in approximately one-third of a second. Considering that a complete breakdown of airflow over the wings occurred (giving a theoretical stall), it would be so momentary that the momentum inertia of the aircraft would prevent serious displacement.

This example demonstrates that the problem of stalling in turbulence is not predicated only on a gust, but more commonly, from the failure of the pilot to utilize proper techniques to maintain the aircraft in a level attitude, at a predetermined turbulent-air penetration speed.

For ease of practical application and after considering all aspects, the maintenance of an airspeed 60 knots in excess of the particular aircraft configuration stall speed, appears to be justified in that it provides a penetration speed approximating V_b, but automatically compensating for the effects of CG, gross weight, and aircraft configuration variables. Maximum airspeed in severe turbulence, with a clean aircraft configuration, should not under any circumstances be maintained in excess of 161 knots IAS (185 mph), or V_b.

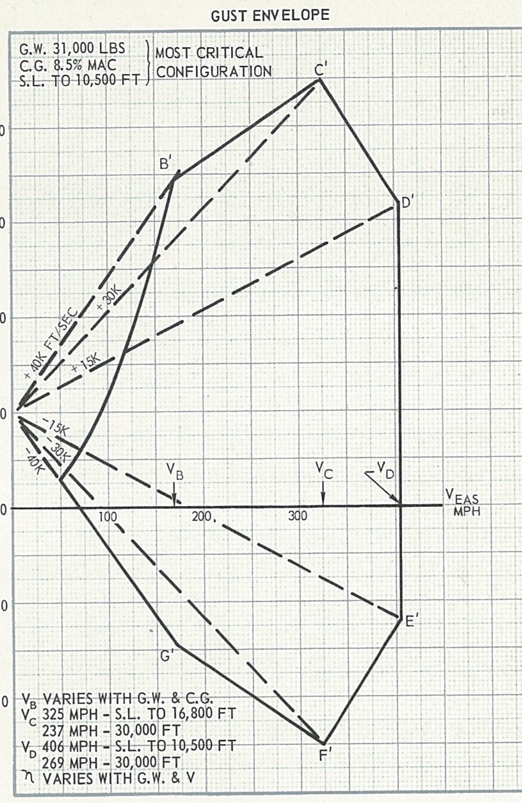


FIGURE 1

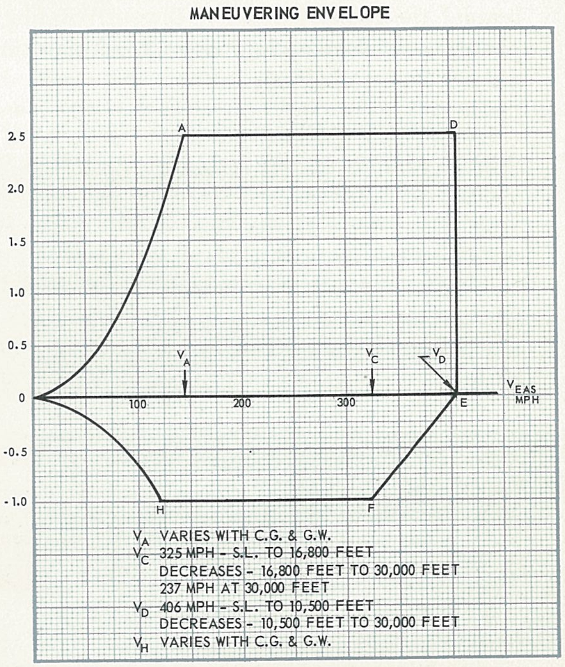


FIGURE 2

THUNDERSTORMS

A thunderstorm is always associated with a large cumulous type cloud that has grown to unusual heights. The vertical growth of the cumulous cloud is due to an invisible rising column of air. Whether thunderstorms are caused by air being heated from below (air mass thunderstorms), or by air being forced up an inclined plane (frontal and orographic thunderstorms), they all have the same general characteristics. These strong updrafts of air, which are the basic cause of the thunderstorm, are offset by downdrafts, both within and outside the thunderstorm cloud. The result is severe turbulence, with the greater portion occurring ahead of the storm in the area known as the "roll cloud."

Eddies that occur along the edge of violent air currents result in the cauliflower appearance of the outside of the cloud. When these vertical currents rise beyond the freezing level of the surrounding atmosphere, it may develop into a cumulo-nimbus cloud, and a thunderstorm is likely.

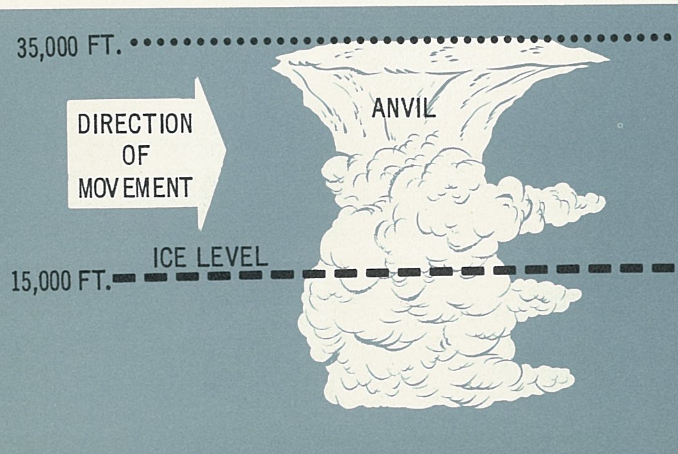
The thunderstorm's identifying features may not always be visible, because they can be masked by other clouds. Low-level clouds may hide the roll cloud, the dark rain area, and the base of the actual thunderstorm. Multi-layer shelves of non-violent cumulous and stratus type clouds often extend for many miles in front of the thunderstorm hiding its anvil top from a low-flying airplane or its base from an aircraft at altitude.

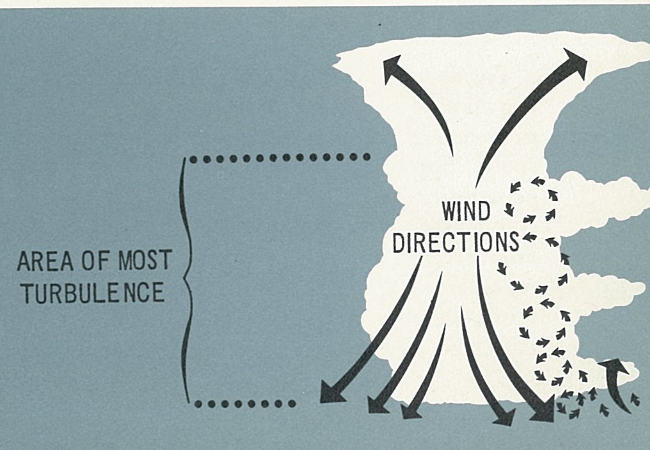
When the atmospheric freezing level is relatively close to the earth's surface, as in the spring and fall of the year, tops of thunderstorms are generally low (15,000 to 18,000 feet). Realistically, these storms are not true thunderstorms, but rather, rainshowers. The formation generally lacks an anvil top and a well-defined or active roll cloud. The entire cloud has a cauliflower appearance with a slight veil of cirrus type clouds around the dome. These storm clouds may contain violent turbulence while they are developing, but gusts are of short duration and lightning is uncommon.

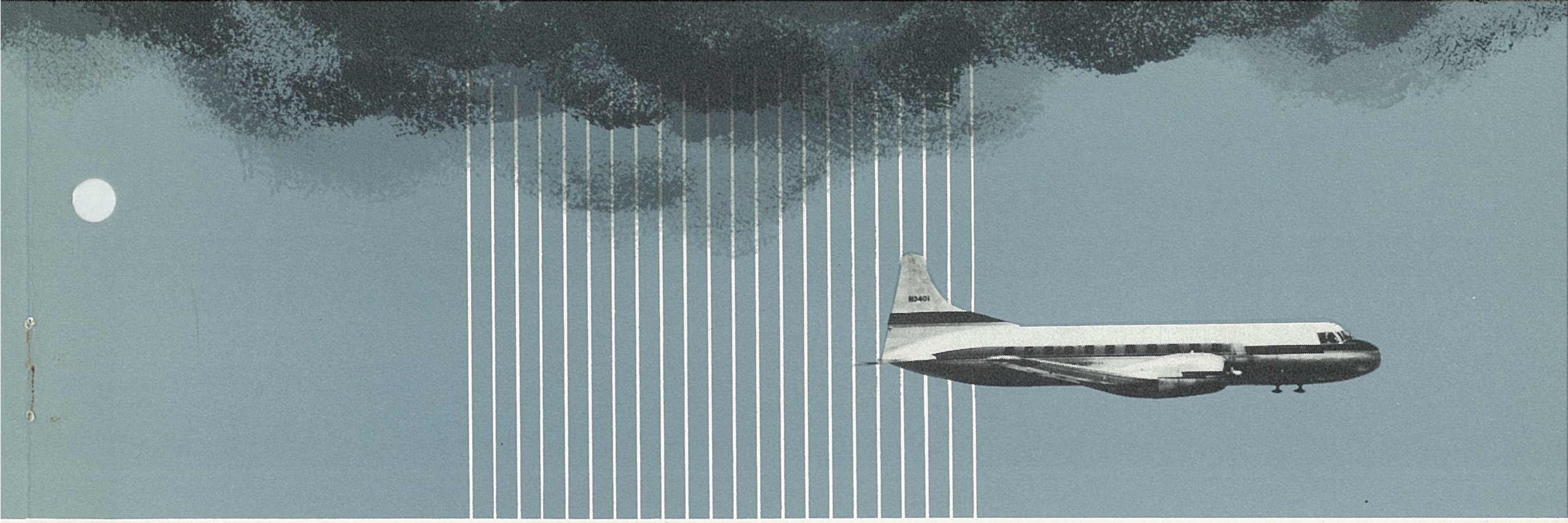
The thunderstorms that build up to 30,000 to 60,000 feet, however, are a different matter. The height to which these clouds extend is primarily governed by the distance between the earth's surface and the atmospheric freezing level. The greater this distance, the higher the clouds and the more violent the thunderstorm activity.

The most violent activity occurs in the lower two-thirds of thunderstorm clouds. If it is 30,000 feet from the base to the top of the cloud, you may expect the greatest turbulence in the lower 20,000 feet.

At night, lightning is usually the first warning of thunderstorms ahead. The region of the most frequent lightning flashes is ordinarily the most violent point within the storm. If more vertical than horizontal flashes are observed, it indicates that you are approaching the storm from the front, where there is greater violence. Conversely, if you see more horizontal than







vertical flashes, you are approaching from the rear. If horizontal flashes are the only type observed, the storm is mild and its base is well above the surface of the earth.

As mentioned previously, the fundamental action required to form a thunderstorm is a strong upward current of air. When air rises, it expands and cools. If it cools sufficiently, the moisture in it becomes visible in the form of clouds. When clouds build up to the freezing level, some of this moisture turns into ice particles, and these become the nuclei for raindrops. If the development continues beyond this point, more energy is developed in the storm and more raindrops form, until finally they begin to fall toward the ground.

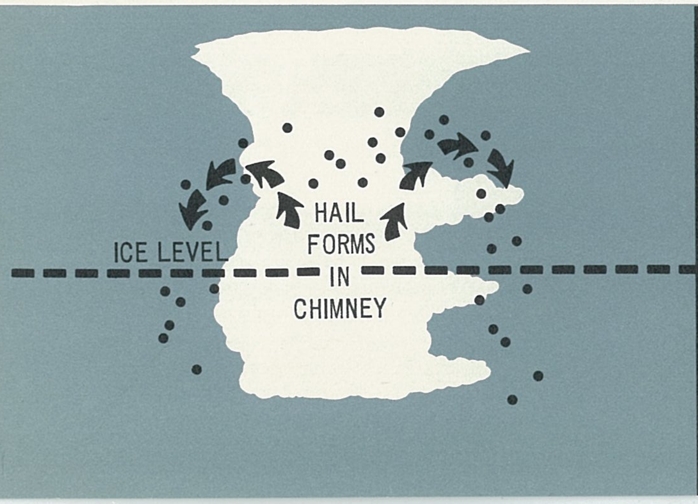
These raindrops cannot fall through air of normal density when it is traveling upward at a speed of approximately 26 feet per second. When large raindrops are falling faster than 26 feet per second against the airflow in a strong upward current, they are blown to bits and the spray that results is carried aloft, because it is lighter than the drops and is therefore more readily airborne. In this process of breaking up, the raindrops produce positive and negative ions of electricity. Thus, in addition to moisture, the cloud now has a static electric charge. When this charge builds up sufficiently, it discharges from cloud to cloud or from cloud to ground in the form of lightning.

The updrafts of air ahead of the storm and the downdrafts within the storm, cause the roll cloud to form at the base of the leading edge. Slightly ahead of this area on the surface, variable and shifting surface winds prevail. In and around the roll cloud is the region of maximum turbulence.

The anvil top of the thunderstorm consists primarily of ice crystals. The anvil top is above the turbulent activity of the storm.

Hailstones are balls or irregular lumps of ice, which may vary from the size of a pea to that of a baseball. Severe aircraft damage from hail, however, is exceedingly rare, for it takes a vertical current of air exceeding 150 knots to suspend the larger hailstones, and ordinarily the updrafts don't exceed 60 or 80 knots. It is possible, of course, for hail to dent the nose, cowl panels, and wing leading edges, with a corresponding loss in aerodynamic cleanliness and efficiency. This is but another reason why areas of thunderstorm activity should be avoided.

Hail forms in the chimney of the thunderstorm, at an altitude above the freezing level. After the hail has once formed, reports indicate it will overflow from the cloud at some point above the freezing level and fall down the sides of the cloud in the surrounding clear air where there are no vertical currents to retard it. In many reports, pilots have experienced heavy hail in the clear air outside a thunderstorm, which seems to support the theory that the worst hail is generally encountered around the main storm cloud and underneath the overhanging shelves, rather than in the region of heaviest rain in the core of the storm.



THE BREAKING UP OF RAINDROPS FORMS A STATIC ELECTRIC CHARGE.

LIGHTNING STRIKES

Numerous reports of lightning strikes have made it possible for the industry to outline a general pattern covering lightning strike damage, the conditions under which strikes are most likely to occur, and how they may best be avoided.

In Convair 240, 340, and 440 aircraft, the nose, loop antennas, and wing tips appear to be the areas most attractive to stray bolts of lightning. The tail cone, rudder, and elevators are the usual discharge points.

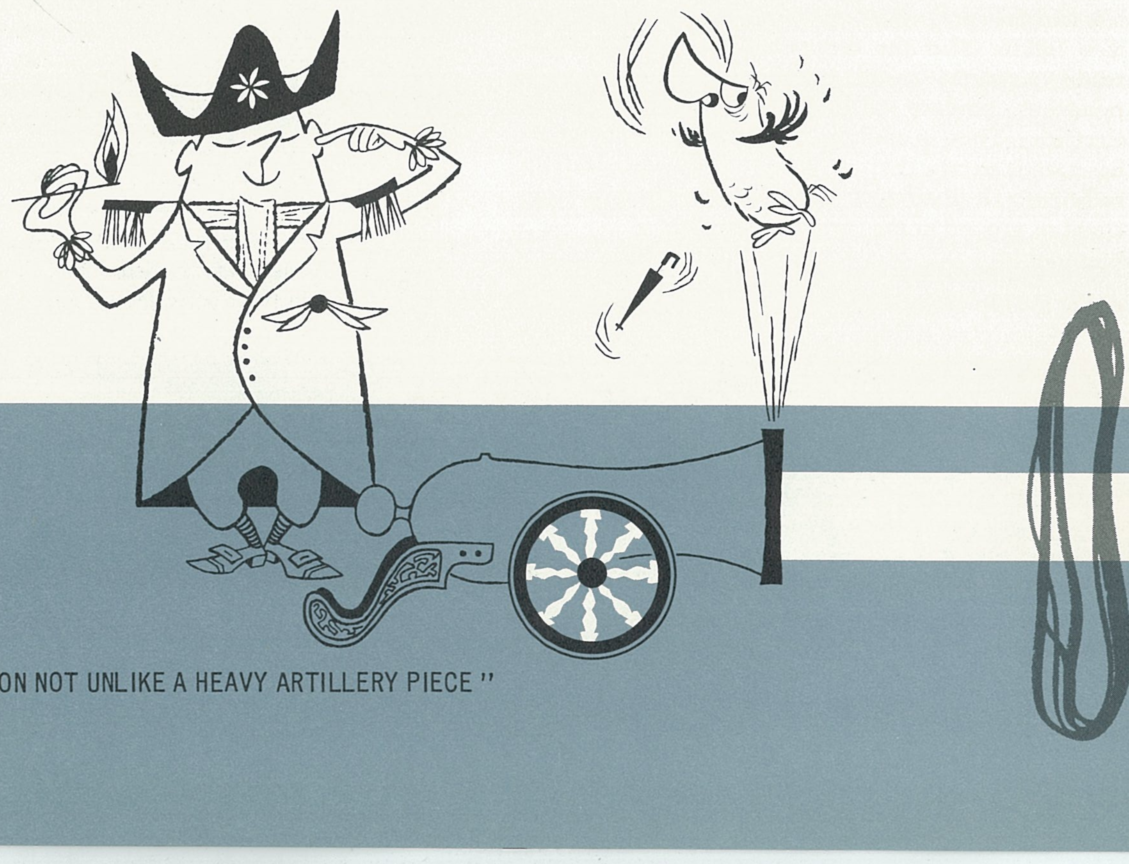
Lightning strikes appear to have a tendency to adhere to a point rather than move around, shifting the point of contact. An airplane traveling 200 mph will cover approximately 290 feet in one second. Considering the turbulent motion of the aircraft in thunderstorm conditions, it is remarkable that the strike terminal remains fixed to one point of the airplane.

Contact and discharge points are usually evidenced by small holes about the diameter of a pencil, burned in the metal skin. However, contacts made on pitot tubes and radio antennas usually cause serious damage to these components. While trailing antennas are common targets, only occasionally have fixed radio antennas been struck. In only a few of these instances, have adjacent radios been damaged.

Evidence obtained from aircraft components struck by lightning in flight, when compared with laboratory test results of the same or similar parts, indicates that the aircraft may be subjected to current peaks of strikes to ground, in the vicinity of 100,000 amperes and to continuing discharges in the vicinity of 500 coulombs (ampere-second).

The effects of this current flow on ball bearings has been proved to be appreciable and should be considered in the event of a pertinent bearing failure on an aircraft with a recent lightning strike history.

The most common resultant of a lightning strike, and one that can cause serious problems in instrument



"... EXPLOSION NOT UNLIKE A HEAVY ARTILLERY PIECE"

flight, is the effect of current flows on magnetic compasses. Subsequent to a lightning strike, a compass will be as much as 30 degrees off on some headings. A valuable item to remember for future reference involves careful planning prior to penetration of a possible thunderstorm area.

Switch gyrosyn compass to directional gyro position and set just before penetration. If the aircraft should receive a strike, the gyrosyn compass will be fairly accurate, even if the magnetic compass is made unserviceable. Even in relatively severe turbulence, the gyrosyn compass generally will not precess excessively and will provide a reliable measure for checking the magnetic compass for induced error.

When lightning strikes an aircraft, there is a blinding flash accompanied by a very loud explosion not unlike a heavy artillery piece being discharged outside the cockpit. A smoky odor (ozone) is usually noticed, but no smoke is observed. It is difficult to accurately tell where the lightning struck the plane, in flight. The copilot will be under the impression it struck the right wing; the pilot will believe it struck the left wing. The flash is equally brilliant on all sides, regardless of the actual point of contact, and can seriously impair night vision for several minutes. It is recommended that all cockpit lights be turned up to full bright intensity, when flying in areas of lightning at night so as to reduce the effects of temporary lightning blindness.

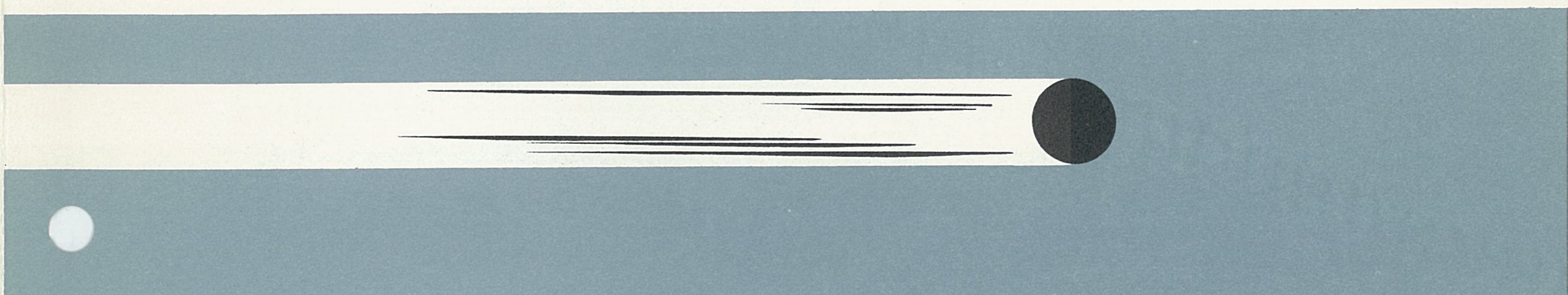
To avoid a lightning strike, avoid flight through cumulo-nimbus clouds at levels with temperatures ranging between +15 and —10° F. Under such conditions, potential gradients and resulting disruptive charges can be expected.

Avoid flights in the immediate vicinity of cumulo-nimbus clouds, especially when they have given indications of thunderstorm activity. It is preferable to keep at least 2500 feet or more away from them.

Avoid flight through moderate or heavy rain and/or snow, hail, or ice crystals, especially at levels where the temperature is from 20° to 40° F, particularly if the precipitation is from cumulo-nimbus clouds.

If precipitation static and/or Corona discharge (St. Elmo's fire) is moderate to severe, and there is evidence from the temperature, cloud, and precipitation conditions that the aircraft is in a zone of strong potential gradient between oppositely charged regions, reduce airspeed to 161 knots (V_b). Then, seek a lower level where temperatures above 40°F prevail, or leave the given cloud and precipitation conditions. The tendency for precipitation static to increase rapidly in intensity, should be regarded as a reliable indication that a lightning discharge may be imminent.

Sooner or later, your aircraft will become involved with a lightning strike. When it happens, make a notation in the Flight Log Book for a visual check of the aircraft, and make certain that the magnetic compass is swung before releasing the aircraft for further flight.



SQUALL LINES AND TORNADOES

Line squalls and tornadoes can provide the worst possible flying conditions, because in their most active stage, during their first few hours of life, they are composed of a continuous line of severe thunderstorms. In addition, there is the possibility that one or more tornadoes will develop in the vicinity of a squall line. *Line squalls are rather difficult to forecast. They occur in all degrees of intensity, but for every severe one there are many of slight or only moderate intensity. The line squall is essentially a cold front phenomenon. Unless cold air replaces warm air and also overruns it, a line squall will not occur. Almost any cold front may be a line squall breeder; however, the line squall may be well past the formative stage before it is identified on map analyses by forecasters. Thus, it seldom appears on 24- and 36-hour forecast maps. *Studies of squalls and successful flights through them indicate there is no preferred altitude or level for penetration of violent thunderstorm activity. While squall clouds occur at a height of 5000 to 7000 feet, turbulence may extend twice as high. *Radar is an excellent aid in determining the location of line squalls; however, it only indicates areas of precipitation, and many pilots believe that if they can avoid these areas they will remain clear of severe turbulence. This is only partially true because a radar echo does not indicate turbulence existing outside the cloud and rain areas of line squalls. When it is absolutely necessary to fly through a line squall, it is better to fly in the thickest part of the thunderstorm rather than in the small clear spaces that may exist between thunderstorms, because there is usually more severe turbulence in or along the edges of a clear space. If the clear space is a mile or more in width, the vertical velocity gradients near the center will probably not be severe enough to prevent safe transit.* A tornado is a violent whirling storm usually a few hundred yards in diameter, having intense cyclonic winds reaching velocities of 200 to 600 mph. Tornadoes differ from hurricanes in both their size and duration. They may occur at any time during the formative stages of a line squall. They result from extreme instability and are usually associated with severe thunderstorms. They apparently grow out of the "roll cloud" as it bends down toward the surface, and usually occur along, or a short distance in advance of a cold surface front between mP and mT air.* A tornado is the most violent of storms, but its life span is exceptionally short, approximately one hour for the average storm, with a track over the ground usually less than 25 miles in length. *Its appearance is so typical and its size so limited, in daylight it is easily recognized and its path avoided without difficulty. Because, like thunderstorms, they travel with the wind, the path of an observed tornado may be roughly forecast, and such areas avoided.

FLIGHT RULES IN AREAS OF TURBULENCE

Thunderstorms present a problem to the pilot that cannot be disregarded. When encountered in flight, thunderstorms and other related areas of turbulence should be avoided by any of the following methods: 1) circumnavigation; 2) Flight below the base of the storm, if a terrain clearance of 3000 feet can be maintained; 3) "Over the top"; 4) A precautionary landing can be made until the thunderstorm passes. The safety and comfort of passengers and crew will depend upon the course of action chosen. The following pertinent conclusions may assist a pilot in making his decision.

1. When encountering cold-front thunderstorms, or other extended lines of thunderstorms, where individual thunderheads are separated by clear areas within accessible altitudes (10,000 to 18,000 feet), flights can be conducted in reasonable comfort through these clear areas and above lower levels of clouds. Do not fly closer than 2500 feet to the cumulo-nimbus build-ups.

2. Do not fly in the immediate vicinity of a thunderstorm or a line of thunderstorms, when below an intermediate level overcast. Thunderstorms have a tendency to expand above stratus type clouds and may release heavy rain or hail outside the actual thunderstorm itself. Severe turbulence may also be encountered due to the instability of air in the thunderstorm area.

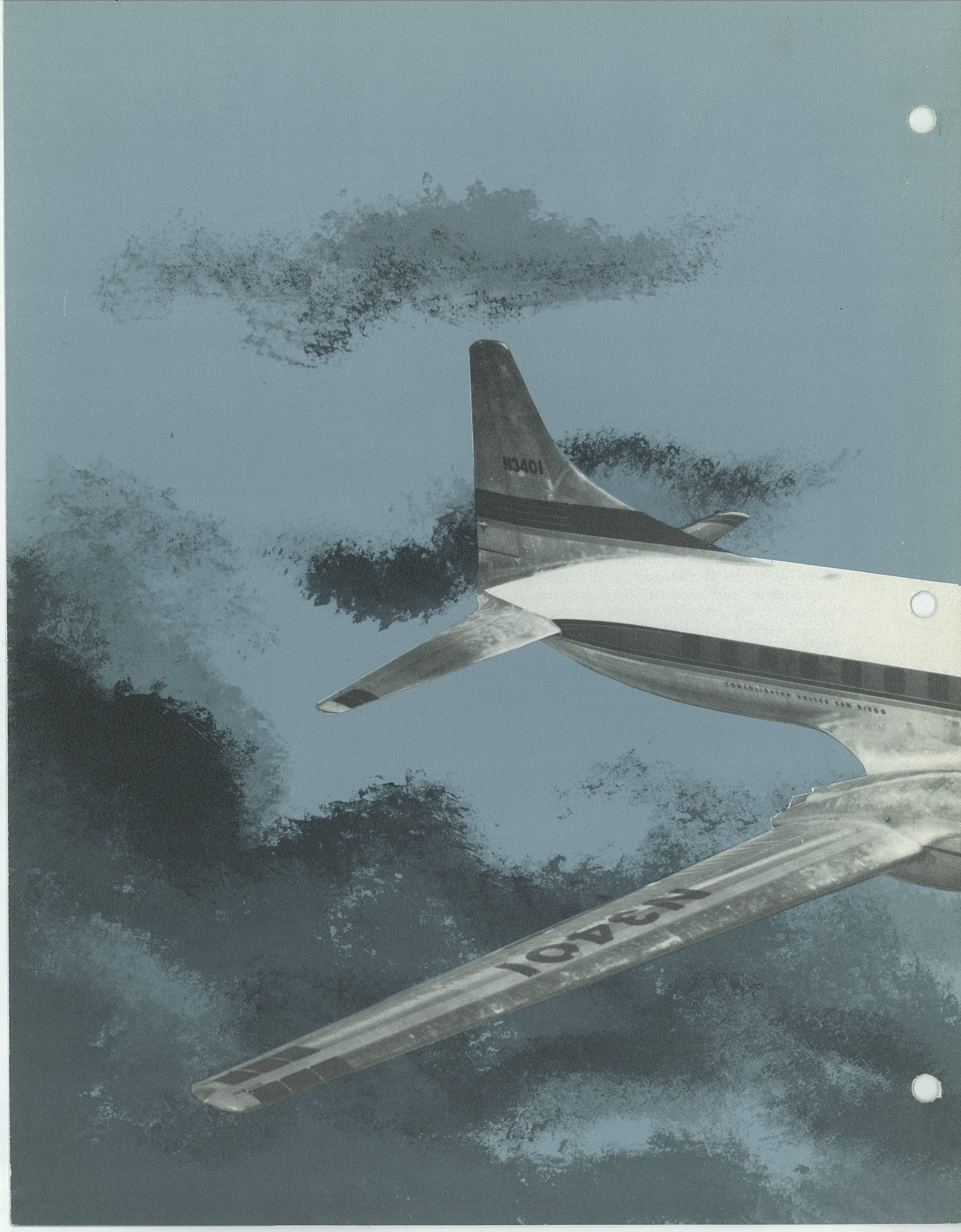
3. Do not attempt flight below pre-frontal thunderstorms or cold-front line squalls.

4. Summertime thunderstorms occurring at night, not associated with any frontal activity, develop at relatively high levels and are usually weak in intensity. Flights conducted below the base of such storms is practical and reasonably comfortable.

5. Extreme care should be exercised when descending toward a thunderstorm with the intention of flying below its base. The normal glidepath of the airplane may be increased by downdrafts, and the rate of descent and indicated airspeed may increase beyond limits. Such descents should be conducted at a greatly reduced airspeed.

6. Never attempt to fly through the "light spots" or "greenish" regions of active thunderstorms. These are generally regions of intense precipitation or hail, with accompanying turbulence.

7. Never attempt to fly through a line squall or cold front thunderstorm unless positive knowledge is had that the individual squalls are loosely connected and can be safely circumnavigated, or unless it is definitely known that flight can be conducted between the build-ups and above the tops of all lower level clouds.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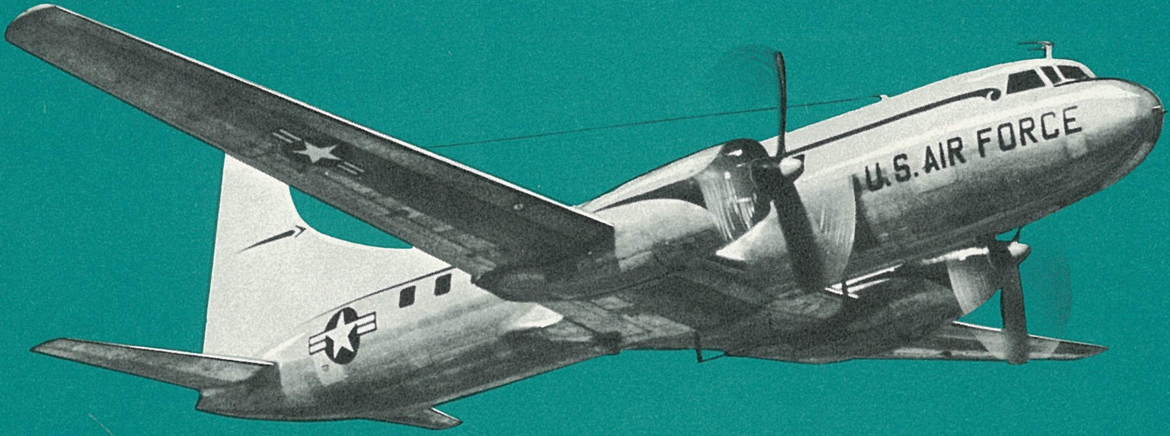

A REPORT ON THE YC-131C

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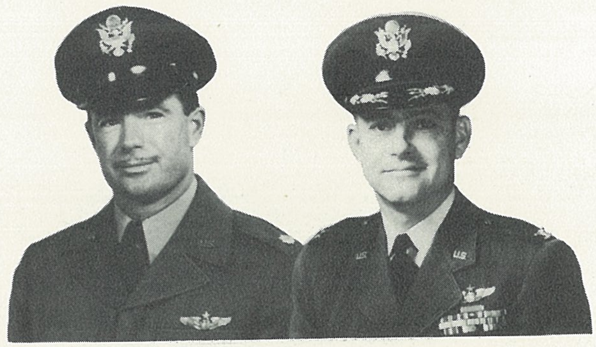
VOL. VII NO. 9 JANUARY 1956



LT. COL. SAMUEL C. BURGESS COL. CLAUDE W. SMITH

FOREWORD

Two Convair YC-131C aircraft completed 3000 hours of flight time in less than eight months. The aircraft were the first to be delivered to the 1700th Air Transport Group of MATS, which was formed for the sole purpose of service-testing propeller-turbine aircraft. The YC-131C is a Convair 340 equipped with Allison turboprop engines.

The Allison YT-56-A3 engines, which power the aircraft, were 50-hour engines at the start of the program. Through service-testing and data gathered by MATS, service life of the engines has been increased to 200 hours, and there is every indication that their utilization will continue to improve.

The excellent results of this test program are attributed to Brig. Gen. Brooke C. Allen, Commander MATS, Continental Division; Col. Claude Smith, Commander 1700th Air Transport Group; and Lt. Col. Samuel C. Burgess, Commander 1700th Test Squadron (turboprop).

Chief Engineer
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C O N V A I R
A DIVISION OF GENERAL DYNAMICS CORPORATION
(SAN DIEGO)

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CONVAIR TURBO POWER

A Report on the YC-131C

Yesterday's airplane is outmoded today just as today's airplane will be outmoded and inadequate tomorrow, because in no industry is progress greater than in the development of aircraft.

Although developments in airframe have progressed since the first biplane, the change within the last ten years has not been as great or as important as that of the power plant. Airspeed, performance, and range are the factors sought in aircraft today and so the trend of necessity is toward power plant development.

Power plant development of reciprocating engines in the last few years has increased at a rate of 100 horsepower per year, while strides in turbine development have been averaging approximately 1000 pounds of thrust per year.

In the power plant comparison chart on pages 104 and 105, the horsepower ratings and weight of reciprocating and turboprop engines are graphically illustrated. As shown, the horsepower-to-weight ratio of turboprop engines is double that of reciprocating engines . . . the turboprop engine producing more than two horsepower for each pound of weight, while the reciprocating engine produces approximately one horsepower for each pound of engine weight.

Since the trend in power development of the turboprop engine is greater than for the piston engine, the strides made in the development of this power plant are an indication of its advantage in present day transports and there is no indication that thrust requirement limits will be reached in the foreseeable future.

The turboprop engine combines the reliability of the piston engine with the higher power producing qualities of the turbine. While it cannot compete with the jet in speed, its lower fuel consumption on long ranges compensates for its lack of equivalent speed. Turboprop engines provide greater thrust at takeoff speeds with an equivalent amount of fuel. Too, the propeller provides high takeoff thrust, and the advantages of thrust reversing for short field landings.

Turboprop engines are being flight-tested today to accumulate operating data on the reliability of turbine-powered aircraft, and to determine the feasibility of converting commercial aircraft to use these new power plants. Analyses of turbine-powered airframe designs and economic and aerodynamic performance improvements of these and existing airframes are presently being studied.

The Convair-Liner 240 was chosen by Allison Division of General Motors to be the first American transport to be powered by turboprop engines. The service-proved Convair 240 was favored over an entirely new airframe for purposes of project accomplishment and low cost as well as for a realistic comparison between reciprocating and turboprop performance. This airplane, the Convair Turboliner, is being flight-tested by Allison.

America's first twin-engine turboprop military transport, the Convair YC-131C, is a Convair-Liner 340 converted to turboprop power. The YC-131C project was initiated for the primary purpose of providing the Air Force with a test-bed turboprop airplane to prove the feasibility of turboprop powered aircraft in military aviation.

Two Convair 340 airplanes were selected for modification to accommodate YT-56-A3 Allison turboprop engines and Aeroproducts propellers. The modification, which was accomplished at Convair-Ft. Worth, represents the minimum rework required to install the turboprop engines in a Convair 340.

The service-proved characteristics of the Convair 340 airframe and equipment made it an ideal vehicle for testing the new type engine because, 1) flight and performance characteristics of the basic airplane were demonstrated and were accurately known; 2) maintenance difficulties of the basic airframe and systems are at a minimum; 3) pilot checkout and familiarization instruction are minimized in light of Air Force experience with the T-29.

These aircraft were delivered to MATS at Kelly AFB, San Antonio, Texas, in January 1955. The 1700th Test Squadron (Turboprop) had just been activated and was composed of a highly specialized, hand-picked group of Air Force personnel, headed by the group commander, Col. Claude Smith, under Brig. Gen. Brooke E. Allen, Commander MATS, Continental Division. On 15 May 1955, Col. Smith turned the command over to Lt. Col. Samuel C. Burgess, who is the present squadron commander.

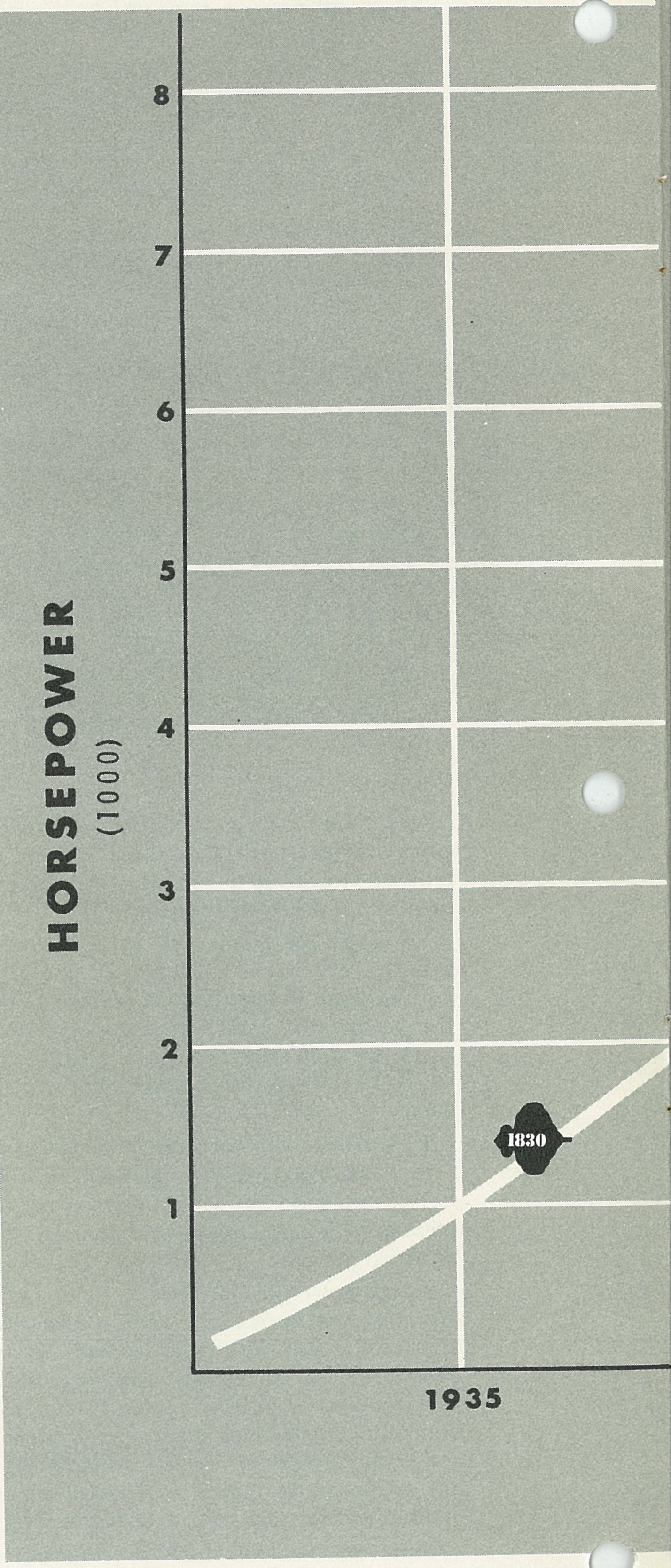
Through a familiarization program initiated by Col. Smith, personnel assigned to the squadron received on-the-job training at Convair, Allison, and Edwards Air Force Base, California. The test squadron was prepared, and all personnel were determined, to obtain maximum time on these aircraft.

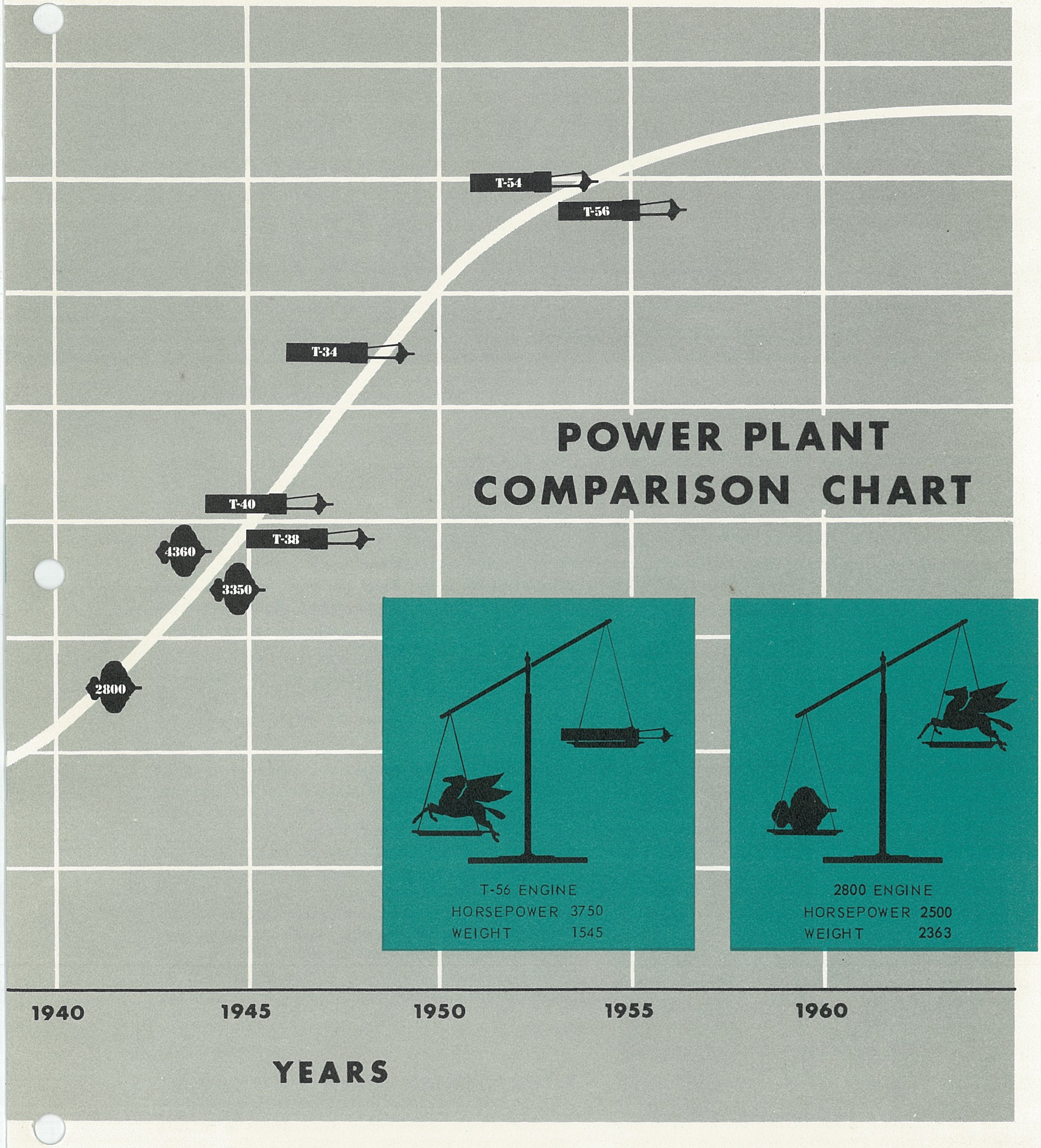
The goal was to obtain 3000 flight hours by 31 January 1955. This meant long hours and hard work for pilots and ground crews, but they were convinced that turboprop-powered aircraft had a place in the Air Force and they were determined to prove it.

Pilots wanted to keep the airplane in the air and so, between scheduled flights to Travis and Andrews Air Force Bases and to the Allison plant at Indianapolis, Indiana, operational flights were made over Texas. With three and four flights a day, aircraft hours mounted rapidly. As a result, by December 20—*45 days in advance of the target date*—the pioneering phase of the program was completed.

And, if this isn't record enough, the Test Squadron established a record in turboprop powered flight—a record that may stand for all types of aircraft. *The achievement*—two YC-131C airplanes accumulated 46 hours and 20 minutes flight time in a single 24-hour period—23 hours and 10 minutes for each airplane. There aren't many minutes left in the day with which to break this record so it is expected to stand unless it is broken by subsequent flights of the YC-131C.

Now that the first phase of the program is completed, the aircraft will move on to other bases for further testing and airline type operation, making way for preliminary testing of other turboprop-powered aircraft.





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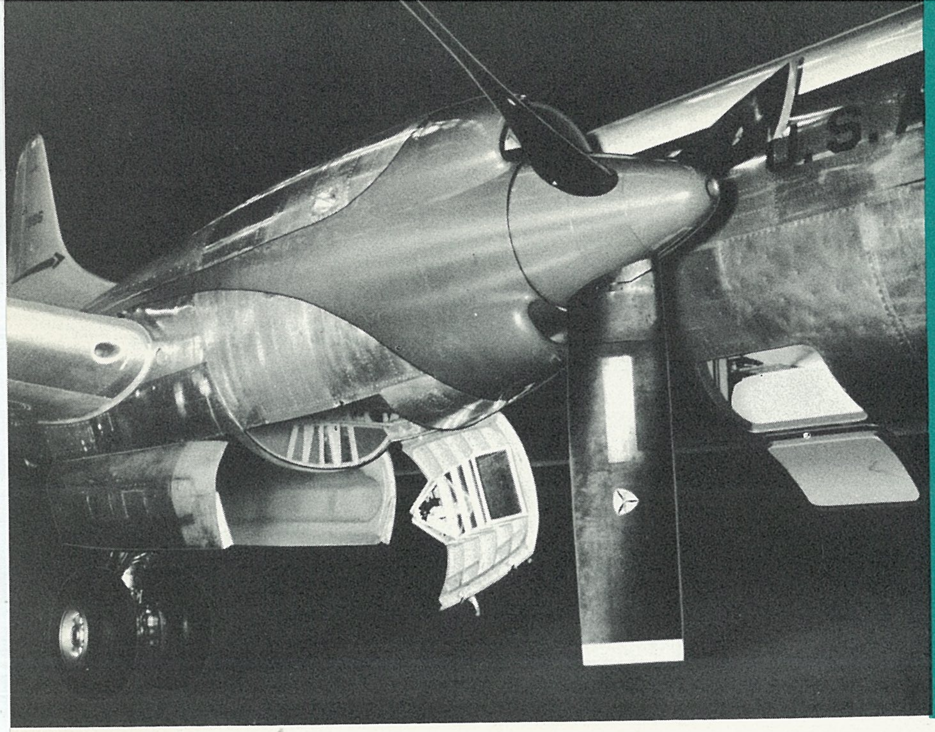


MODIFICATION PROGRAM

Modification of Convair 340's to YC-131C test airplanes was accomplished at Convair-Ft. Worth. Portions of the airframe and airplane systems not directly affected by modification remained in their CAA-approved commercial configuration. Both airplanes were certificated by the CAA before modification and have been flown within the gross weight limits established by the CAA.

Installation of the YT-56 turboprop engines required removal of the original nacelles, with the exception of that part that forms the landing gear enclosure. A new semi-monocoque nacelle was designed to support the engine and to house the accessories.

The burner and turbine sections of the engines are completely isolated from adjacent compartments by stainless steel firewalls. The aft section of the engine is readily accessible for maintenance through a large hinged door located at the top of the nacelle. Accessibility to both the power plant and the reduction gear box is gained through a large door on the bottom of the nacelle.

In addition to installation of specially designed engine nacelles, the following modifications were necessary.

Engine Controls

The pilots' pedestal was altered to suit turboprop requirements. As in all turboprop installations, power control consists of a single power lever for each turbine. The angular travel of the lever is divided into two parts. The forward part controls the engine between operational idle and full power; the after segment, reached by lifting the throttles, places the propeller in the BETA regime for taxiing, starting, and reverse thrust operation. The propellers operate at constant speed and the blade angles are directly controlled by power lever positions, constant speed being maintained automatically at all times through the coordinating control.

A turbine inlet temperature gage indicates temperature of the gases after burning in the combustion chamber and about to enter the turbine. This gage and fuel flow indicator are the two instruments used for setting powers.

A highly sensitive torquemeter measures torsional deflection in the shaft by magnetic pickups that are calibrated in horsepower. An autofeathering system relieves the pilot of windmilling drag if an engine should fail at takeoff. This is the same system that has been proved on all Convair-Liner type aircraft. A "speed sensitive" switch senses turbine speed drop, if engine power loss occurs, and sends a signal to automatically feather the propeller, at the same time shutting off fuel, oil, and hydraulic fluid. With the completely automatic feathering system, the pilot is relieved of many details.

Fire Extinguishing

Increased nacelle volume, plus changes in air flow through the nacelle due to altered engine requirements, necessitated a redesign of the existing fire extinguishing system to provide sufficient agent to meet

the requirements of MIL-E-5352A. Essentially, the difference between the two systems lies in the weight of the agent dispensed in a single shot—22.5 pounds for the Model 340 and 38 pounds for the YC-131C. The YC-131C has two 19-pound spheres in each wing fillet as compared to two 22.5-pound containers in the left-hand wing of the Convair 340. This system provides three-zone coverage instead of the two zones neutralized on the CV340. The methods of discharging the agent, discharge indication, agent routing, and agent distribution remain essentially the same for both installations.

Instrument Panels

The major change to the pilots' instrument panel was the replacement of the center engine instrument panel with a new panel using two-inch jet instruments. Warning lights for primary fuel pump failure, and fuel-pressure-low indicators were added. The co-pilot's instrument panel, immediately to the right of the center engine panel, was modified by adding a triple indicator in an existing space provision. This indicator gives readings of cabin compressor oil temperature, compressor rpm, and compressor bearing temperature.

A great many instruments are eliminated because control of the engine is simple. The pilot has one lever with which to control engine power. There are no separate mixture levers, propeller speed selectors, magneto switches, carburetor heat controls, or any of the power plant controls associated with conventional aircraft.

Pilots' Pedestal

The pedestal was altered by the installation of a new power control quadrant, which incorporates a lift-up feature at the *flight idle* position. Besides the individual power control levers, there are two condition (feather) levers located at the center of the quadrant for operation by either pilot. Air start (unfeather) is accomplished by moving the condition levers forward to the normal ("run") position.

An anti-creep mechanism is incorporated on the power lever.

The control cable installation remains substantially the same as that on the Model 340 except for changes in routing necessitated by different engine controls. The actuating mechanism for the engine coordinator, located on the nacelle firewall, is replaced by a new installation.

Control Surfaces

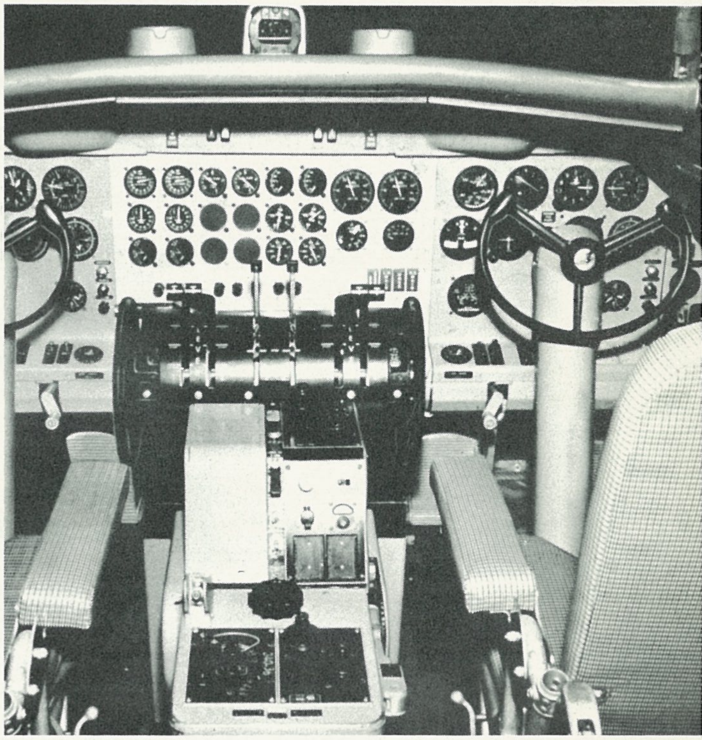
In order to accommodate the increased horsepower provided by the Allison turboprop engines, it was deemed wise to increase the area of both the fixed and movable empennage surfaces.

The rudder chord and height were increased approximately 5 inches and 12 inches respectively, thus increasing the rudder area by 12 square feet. The elevator area was increased approximately 17 square feet. Empennage controls are the same as those on the Convair-Liner 340 commercial airplane.

The fin height and the horizontal stabilizer span were increased 12 inches and 40 inches respectively. The rudder includes a manual trim tab at the top and a servo tab at the lower trailing edge. The elevators have a servo tab on the left-hand side and a servo trim tab on the right-hand side. Actuation of the empennage controls remains identical to that on the commercial airplane.

Electrical System

The Convair 340 electrical system was adapted to meet the requirements of the YC-131C airplane by modifying existing electrical panels, racks, junction boxes and wiring. The following new equipment was



added: 1) an equipment rack in the upper forward cargo compartment for two temperature datum control amplifiers and two propeller governor amplifiers; 2) a 1500-volt-ampere three-phase inverter installed just forward of the two existing inverters for propeller feather pump-motor power, and as an alternate power source for engine and propeller control amplifiers; and 3) a fuse panel, required for the added inverter, located on the relay panel for access in flight.

Wiring changes were made and circuit breaker and switch panels modified to accommodate the electrical changes.

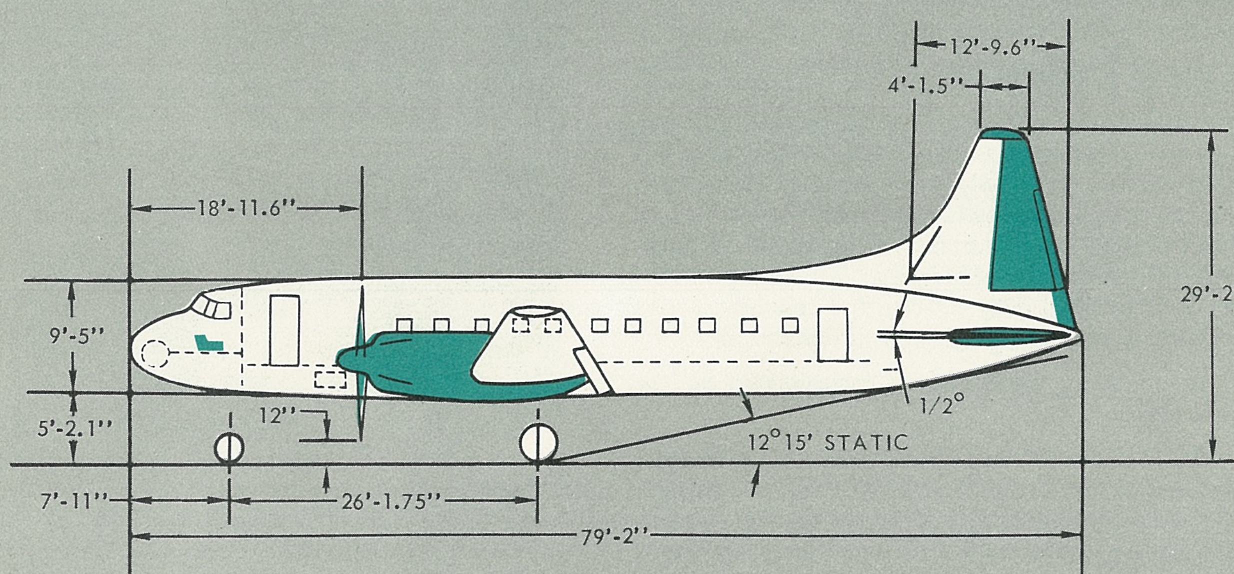
Cabin Pressure, Heating, Ventilating

Cabin heating remains the same as on the CV340 except that hot air is taken from the engine compressor, instead of from the engine exhaust augmentors. Since the compressor bleed air has sufficient pressure to flow at any time the engines are running, it is not necessary to operate the ground ventilating fan to obtain ground heating as required on the 340 airplane. The heating air ducts also function as starter manifold ducts when the starter arming switch is engaged. This permits the starting of one engine from the other operating engine. A ground service air connection for engine starting is located in the right-hand wheel well.

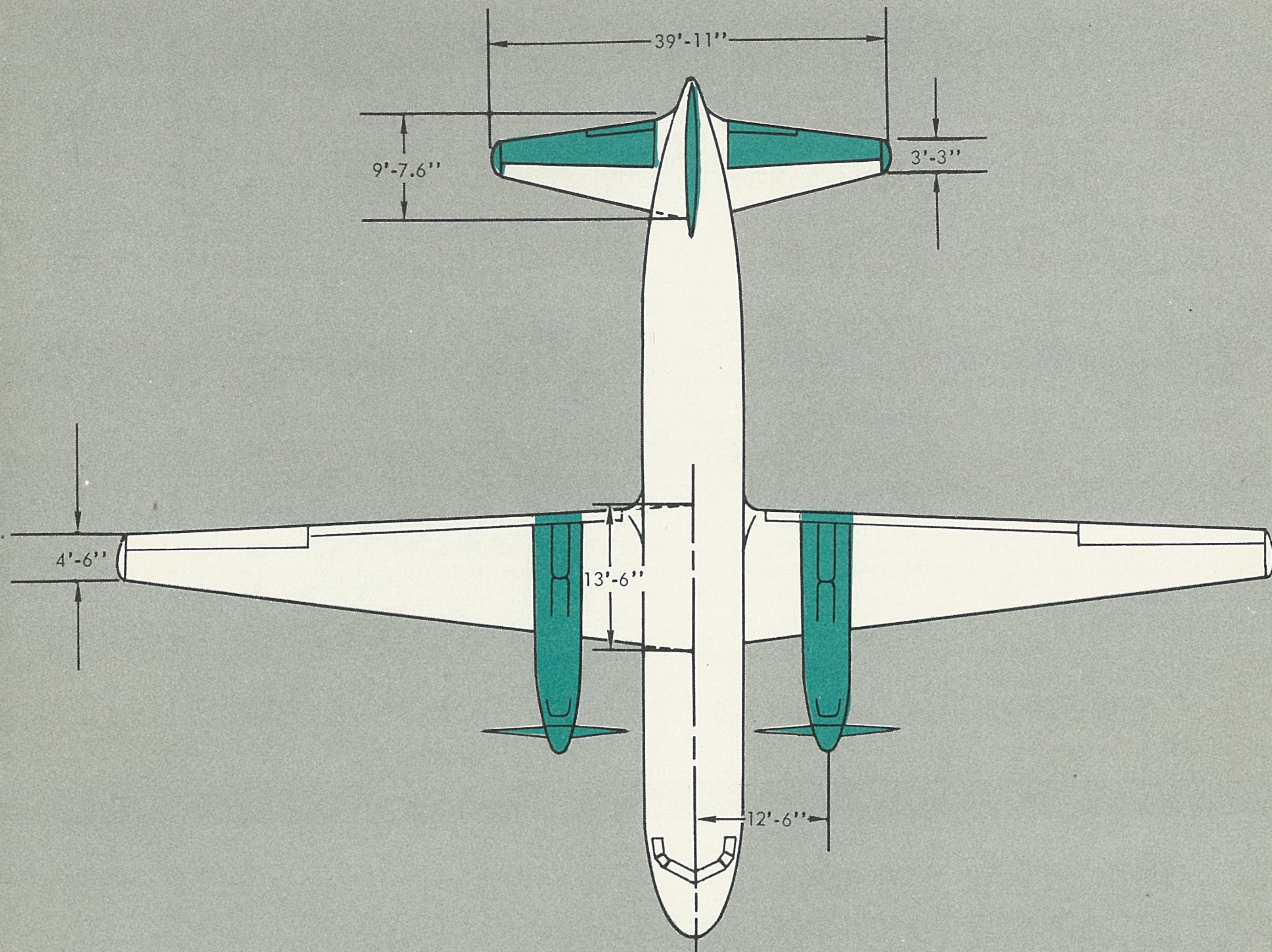
The cabin compressor is designed for direct attachment to and operation from an accessory drive pad on the right-hand engine. This compressor is a single-stage, radial-flow type that incorporates a variable-speed drive to provide for constant air flow under varying cabin pressure conditions. This variable-speed drive is necessary since engine drive pad speed on the YC-131C is constant. Pressure ratio control of the compressor is automatic.

The pressurized air is heated or cooled, as necessary, in the same manner as on the Convair 340 airplane.

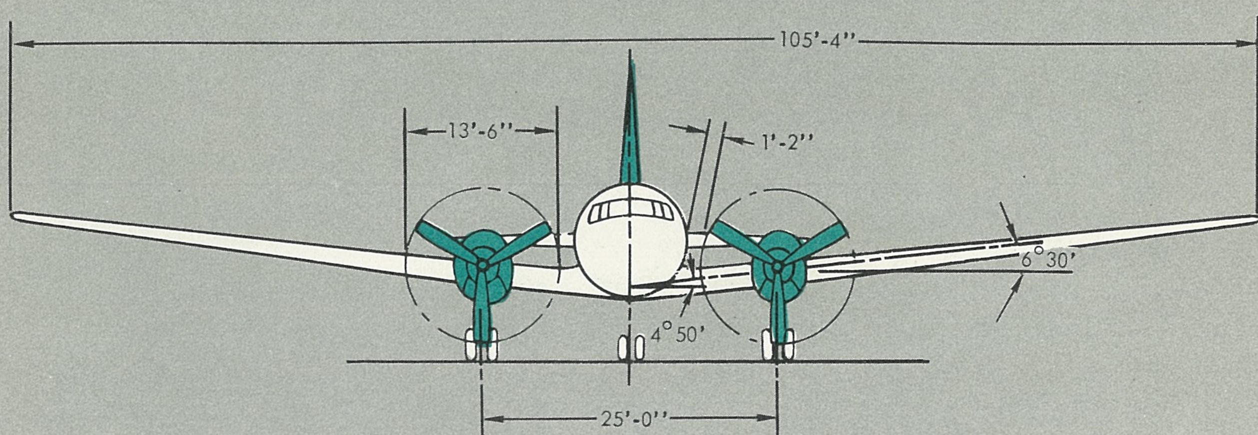
YC-131C THREE-VIEW



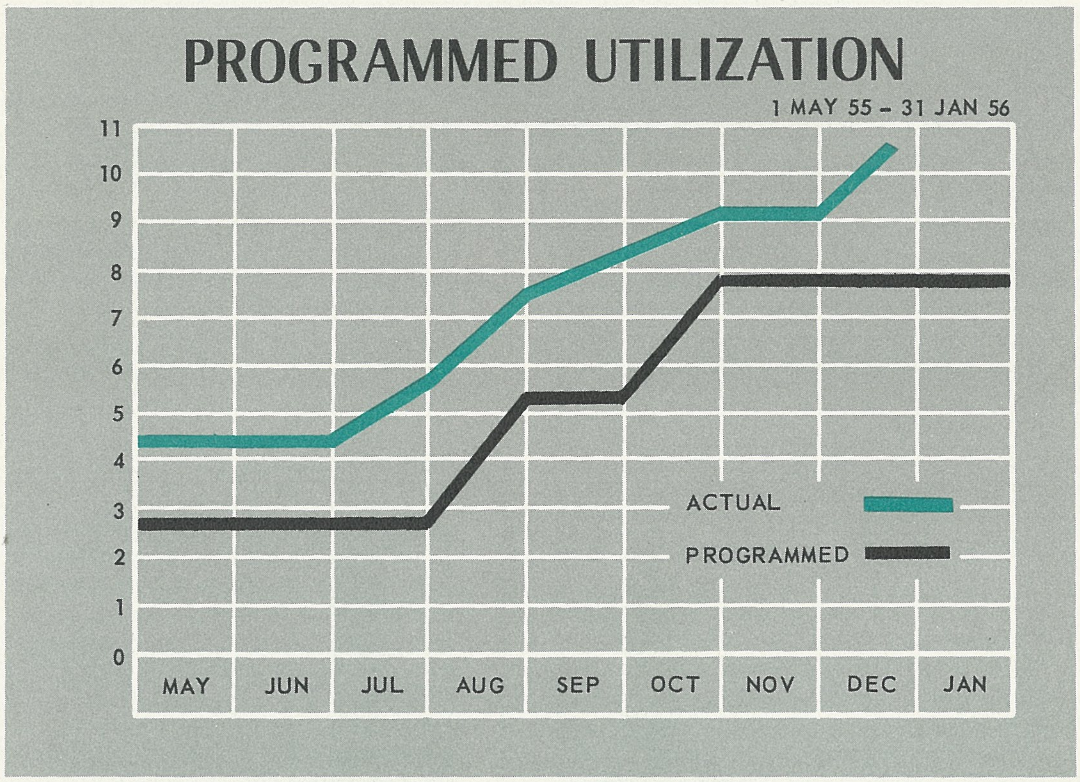
GREEN PORTIONS INDICATE AREAS OF MODIFICATION

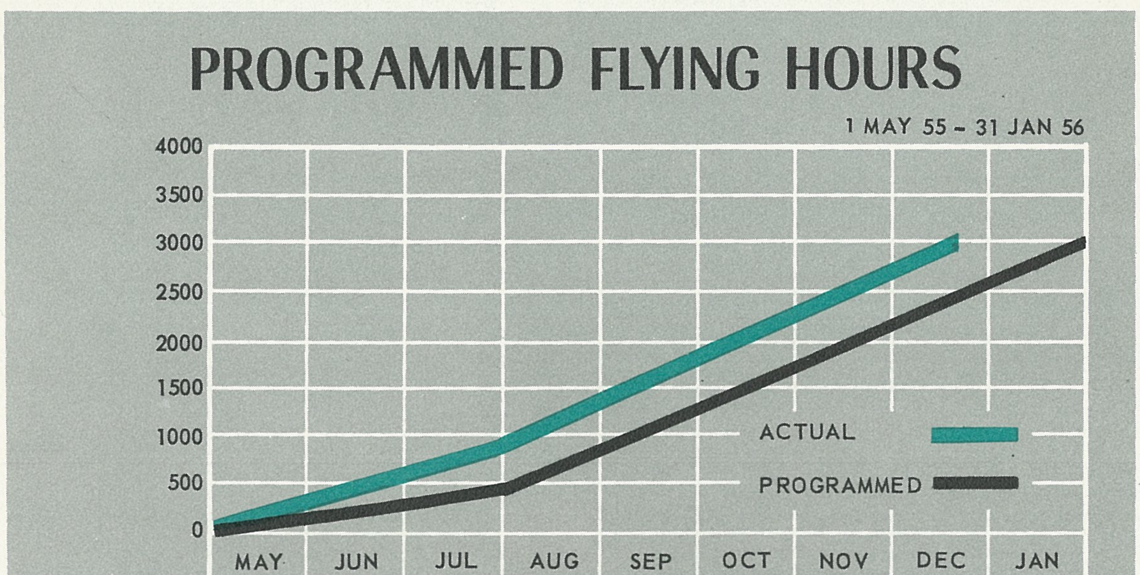


39'-11"
9'-7.6"
3'-3"
4'-6"
13'-6"
12'-6"

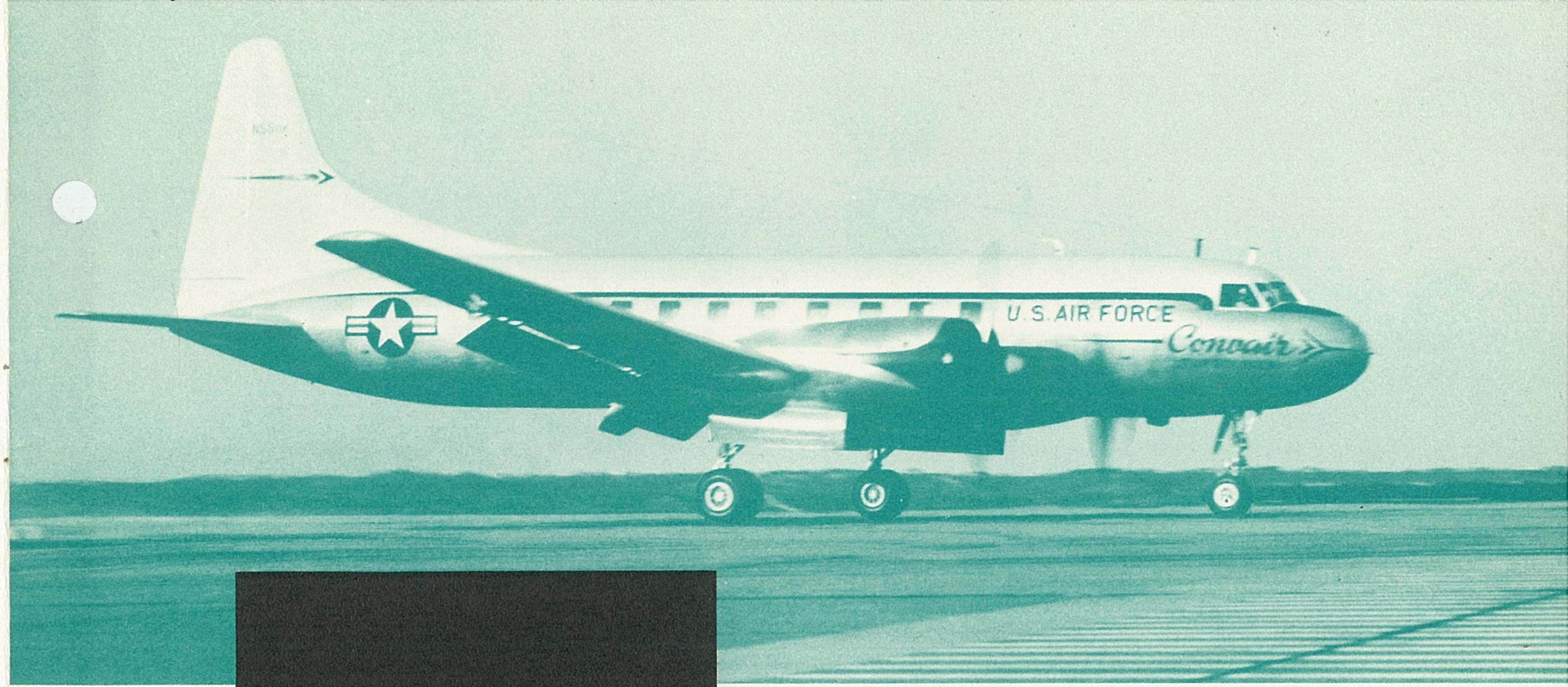


105'-4"
13'-6"
1'-2"
6° 30'
4° 50'
25'-0"





	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN
PROGRMD	160	160	160	315	315	472	472	472	472
ACTUAL	275	262	347	468	406	491	539	212	



SUMMARY

In the exhaustive flight testing by MATS crews, the airplane has flown to 39,500 feet and has taken off many times at over 50,000 pounds gross weight; during the initial flight test phase at Ft. Worth, the airplane was dived to 376 mph; it has flown in level flight with restricted engine powers at over 340 mph.

The takeoff power on the production T-56 engine is 3750 equivalent shaft horsepower. The YT-56-A3 engine in the YC-131C has been operating at a restricted power of 3250 ESHP.

Takeoff at 47,000 pounds gross weight requires 2710 feet to clear a 50-foot obstacle. The airplane climbs to 25,000 feet in less than 15 minutes. Landings have been made in which the use of reverse thrust resulted in a landing roll of only 700 feet. This is made possible by reversal action which results from positive transition from forward to reverse thrust without danger of engine stalling.

With production Allison Specification power, the airplane has a high speed of 390 mph. This speed is obtained at 25,000 feet with military power and 43,000 pounds average gross weight.

The service ceiling with both engines operating is 36,000 feet; with one engine, 18,000 feet.

The range at an operating speed of 330 mph with 80 per cent normal rated power at 30,000 feet and with full fuel load is 1970 statute miles. By increasing the amount of fuel in the wing and adding wing tip tanks, the all-out range can be increased to 3450 statute miles.

A great many high-speed transports, powered by high SHP turboprop engines will be flying domestic airline routes as soon as military needs are satisfied. The same basic turboprop configuration that is used on the Air Forces version of the Convair-Liner 340 could be offered to Convair-Liner operators in kit form. All of the information and experience acquired with the YC-131C and the Turboliner can be developed and incorporated in the kits.

Another Model 340 turboprop modification is being made in England by Napier-Eland Ltd. Turboprop engines of the 3000-4000 ESHP class are being installed in a manner similar to the YC-131C modification. European operators particularly, are watching this kit-type installation of turboprop engines in a service-proved commercial airliner. Present plans call for the first flight this month.

Costs of turboprops will be within the reach of commercial operators since, in production, these engines could be produced for the same cost per pound of engine that applies to any other engine of similar power. This means that, with the low weight per horsepower of turboprop power plants, these engines will be lower in cost than reciprocating engines of comparable power or, weight for weight, a turbine of considerably more horsepower can be purchased at the same price.

Convair is firmly entrenched in the military and commercial air transport field and is constantly looking ahead. All future designs include some type of gas turbine power plant. The high performance and economical short- to medium-range turboprop transports in company with a long range aircraft will make a formidable team for any future airline equipment plan. Whether it be a new airplane or a continuation of the minimum change to existing airframe philosophy, Convair plans to stay in the turbine-powered air transport field.

Two Convair YC-131C turboprop Air Force transports flew a total of 46 hours and 20 minutes within a 24-hour period in a rapid turnaround operation at Kelly Air Force Base. The two airplanes made six refueling stops, averaging 17 minutes per stop, although one refueling was accomplished in eight minutes. Besides refueling, oil was checked, engine and airframe visually inspected, and crews changed at each stop. The accelerated flying was to determine the requirements for propeller-turbine aircraft in an operation necessitating rapid turnaround.

CONVAIR
Traveler
VOL. VII NO. 11 MARCH 1956

11 43

the NEW LOOK

CONVAIR *Traveler*

VOL. VII   NO. 11   MARCH 1956

FOREWORD

In this issue, Convair introduces the Metropolitan "440," a modern airplane designed to meet the needs of many airlines for a modern high-speed transport with maximum performance flexibility. All of the features found in the Convair-Liner 340, in addition to improved range, performance, and latest advancements in sound suppression and aircraft safety, are found in the Model "440."

The Metropolitan "440" offers the most economical direct operating cost of any short- and medium-range aircraft.

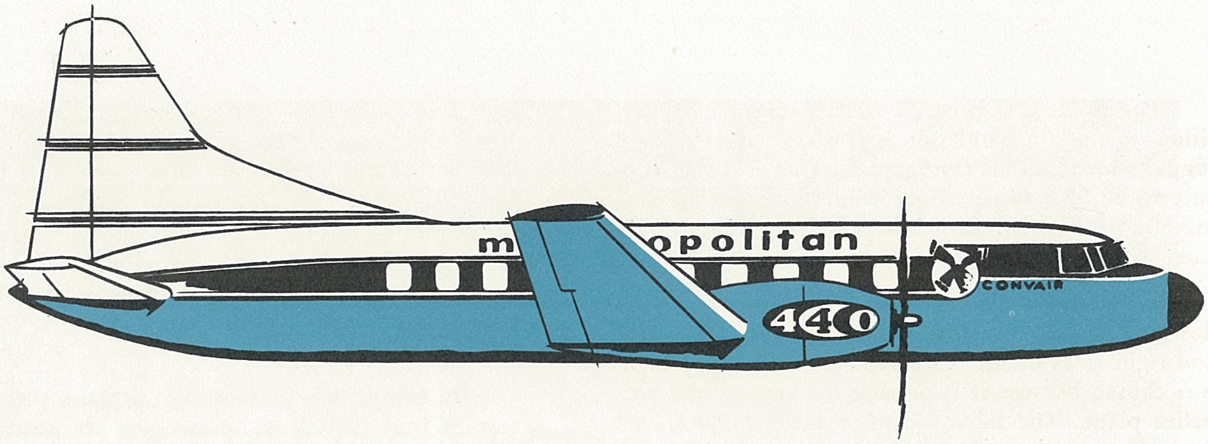
Chief Engineer
R. L. Bayless

Chief of Service
J. J. Alkazin

Editor
G. S. Hunter

ON THE COVER
Darrell Burchfield takes artistic license to give you a preview of the new look in aircraft — Convair's new-look Metropolitan "440."

A digest of Convair-Liner operation and service published monthly by the Service Publications Section of Convair in the interest of Convair-Liner operators. Communications should be addressed to Chief of Service, Convair, San Diego 12, Calif.



the NEW LOOK ... "440"

Convair has in production an advanced model of the Convair-Liner, designated the Metropolitan 440. In this new versatile model, operators are offered their choice of the standard 44-passenger version, or the newly-designed, expanded seating capacity model, which will accommodate 52 passengers and a crew of four.

The Metropolitan incorporates the operating economy and high performance of the Model 340, plus the latest advancements in sound reduction. The gross weight of this airplane has been increased to a maximum of 48,000 pounds with CB16 engine ratings, and to a maximum of 49,100 pounds with CB17 engine ratings.

Many other improvements resulting from service experience gained with large fleets of Convair-Liner 340's have been incorporated in the "440" to give it a more competitive position in airline service.

The features that have given Convair transports one of the best operating records of any commercial aircraft and the lowest operating costs in the short and medium range transport field have been carried over to the Model 440. As with other Convair-Liners, the Metropolitan will have an integral loading stairway, which was first introduced on the Convair 240. This door and ramp installation has found favor with airline management and the flying public alike. This stairway, plus accessible luggage racks (on the 44-passenger version), offers passengers their choice of carrying their luggage aboard or checking it in the usual manner. These same passengers can pick up their luggage and deplane in less than three minutes.

The Model 440 is not a "high density, low-fare coach service" airplane with seats on tracks. All seats are the same full size, easily-detachable type found on all Convair-Liner 340's. With two exceptions, the same space interval as that of the Model 340 is maintained on the 52-passenger version. Between the row of aft-facing seats and the first row of forward-facing seats, 25 inches is provided. To gain this additional spacing between the facing seats, the area between the second and third rows has been reduced to 35 inches instead of the standard 38 inches.

With the exception of the front-row aft-facing seats, which are stationary, all seats are reclinable as on the Convair 340.

The station 243 partition is so designed that it can be easily relocated to facilitate conversion to either the 44- or 52-passenger model. On the 52-passenger version, the "No Smoking - Fasten Seat Belt" sign at station 243 is double-faced so that it may be seen by aft-facing passengers. An additional sign is installed at station 176.50 for those forward-facing passengers forward of the station 243 bulkhead.

A draw curtain is provided at the forward end of the passenger compartment. The curtain extends over the coat-luggage compartment doorway.

In the 44-passenger configuration, the coat compartment is opposite the luggage racks. In the 52-passenger version, two coat rack rails are provided in the compartment which is located between stations 131 and 176.50 on the right-hand side. This area, which may also be utilized for luggage, is the forward cargo area on the 44-passenger airplane.

The floor area forward of the station 243 partition on the left-hand side is stressed for cargo and luggage loads on all configurations; thus, when converting to the 44-passenger configuration, the area may be utilized for cargo or may be equipped with carry-on luggage racks.

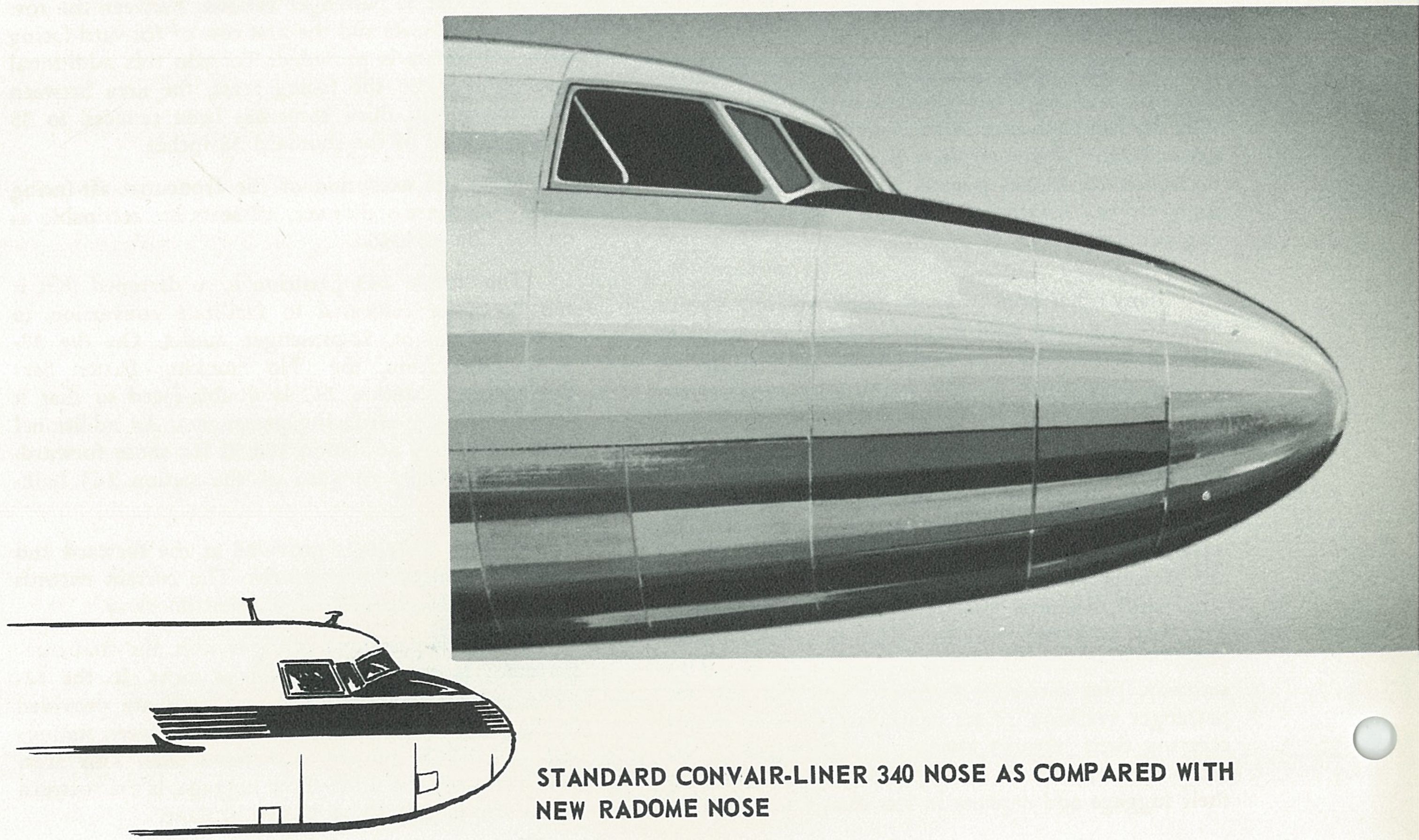
In the 52-passenger version, an additional window is installed between stations 193 and 213, left and right sides of the fuselage. This forward position was chosen because it is outside the area of the propeller plane. The bulkhead at station 243 is moved forward to station 176.50 to accommodate two additional rows of seats.

One of the most outstanding "new look" features of the Metropolitan "440" is the streamlined radome nose which houses the airborne weather mapping radar. Airborne radar permits the pilot to avoid turbulence, damaging hail, and tornadoes by detouring these areas with minimum deviation from the flight path. He can scan a storm area as far away as 150 miles, thus giving him sufficient opportunity to detour with little increase in flight time. If the storm front encompasses a large area, he can choose a corridor of mildest activity, usually without deviating from the planned flight plan. The installation allows penetration of 15 miles or more of heavy rain; thus the pilot will not be led blindly into the hard core of a storm.

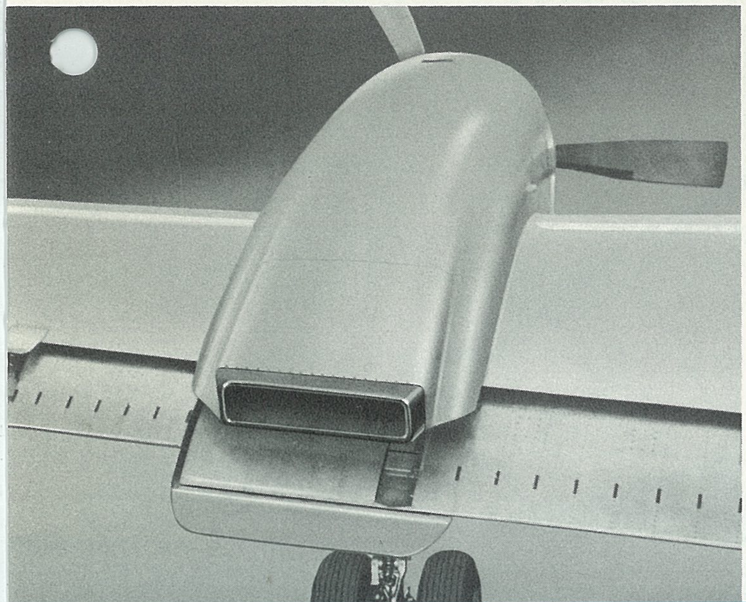
By being able to route an airplane through an area of least turbulence, passengers are assured of a relatively smooth flight without the disturbances of lightning strikes, hail, and buffeting.

The radome extends approximately 28 inches forward of the conventional nose. It is hinged at the top so that it can be raised 90 degrees. The pressure-tight bulkhead to which the radome is attached, carries the supporting structure for the radar antenna scanner.

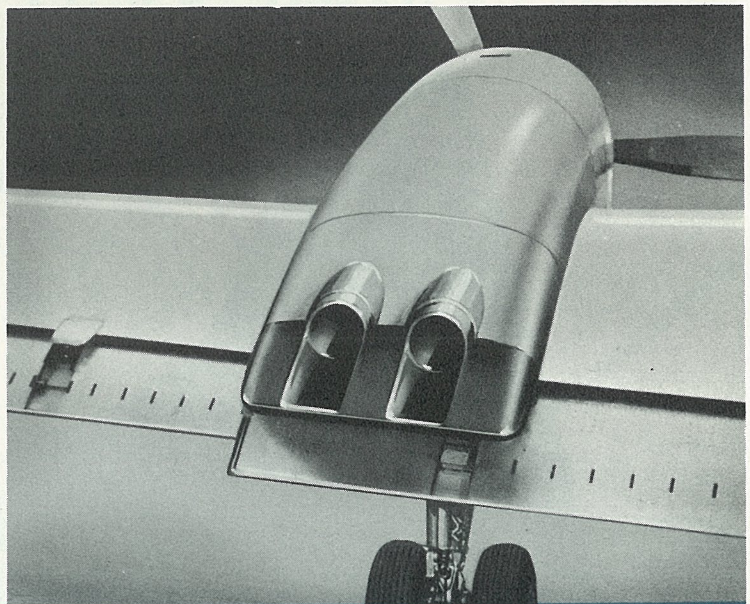
....*The* NEW LOOK



STANDARD CONVAIR-LINER 340 NOSE AS COMPARED WITH NEW RADOME NOSE



"440" NACELLE SHOWING RECTANGULAR EXHAUST SILENCER



CONVAIR 340 NACELLE SHOWING CIRCULAR EXHAUST OPENINGS

and what it does!

The radar installation accommodates the RCA AVQ-10, Bendix RDR-1, or the Air Force APS-42 radar antenna and scanner. The electronic equipment for the scanner is mounted on the radio rack.

This feature may be incorporated at the operator's option.

Airline operators will note a new look in Convair's nacelle. The exceptionally clean aerodynamic lines of the nacelle are further streamlined with a rectangular exhaust silencer at the aft end, in addition to an increased taper at the forward end.

The exhaust silencer is the outstanding item in the new sound suppression techniques developed by Convair and the firm of Bolt, Beranek, and Newman, Inc., acoustics engineers of Cambridge, Massachusetts. The mufflers with a single rectangular opening at the end of each nacelle instead of two circular openings provide reduced sound levels throughout the passenger cabin.

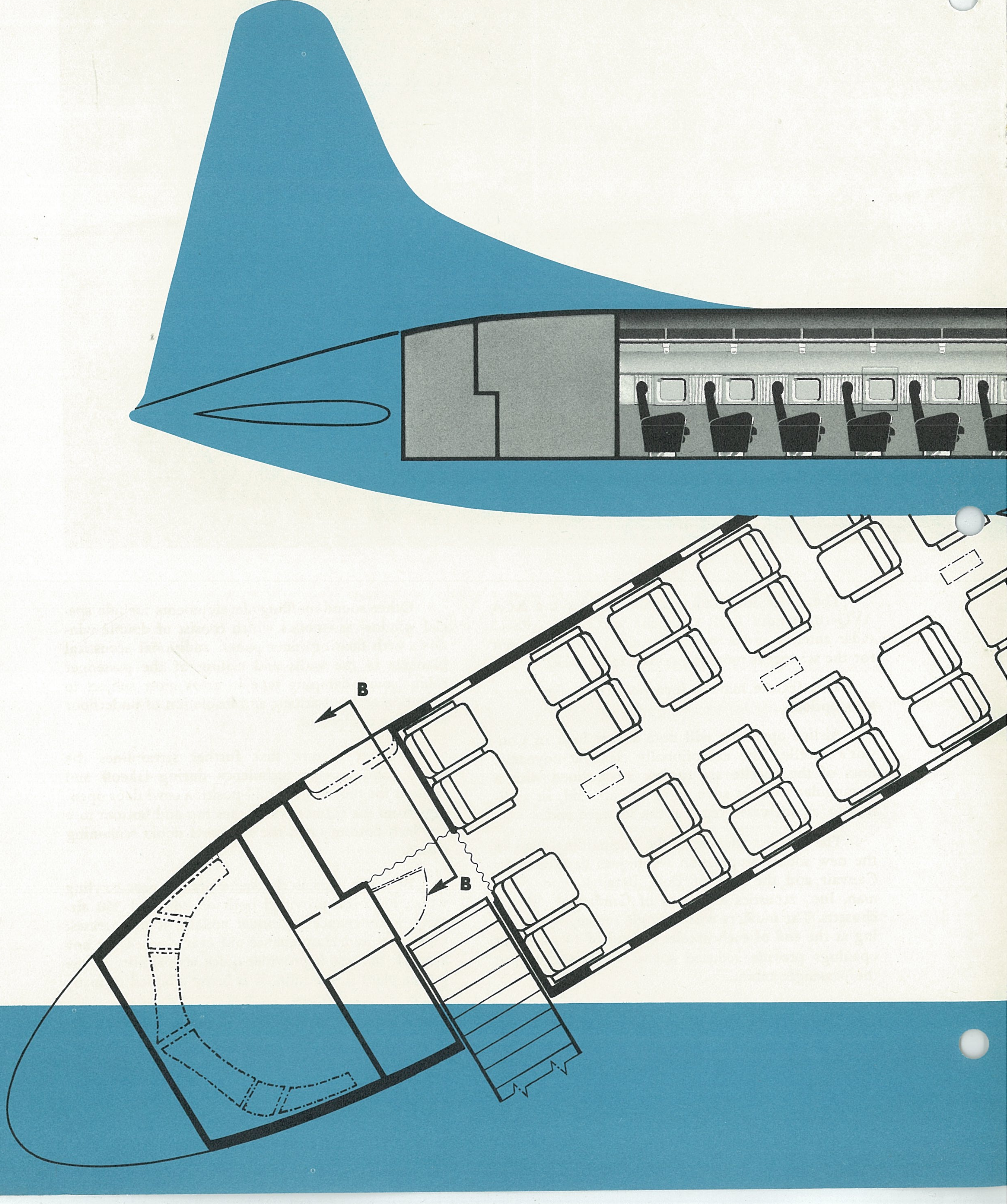
Other sound-muffling developments include special window assemblies which consist of double windows with floating inner panes; additional acoustical blankets in the walls and ceiling of the passenger cabin; sound-damping tape in areas most subject to vibration and pulsations; and insulation of underfloor operating equipment.

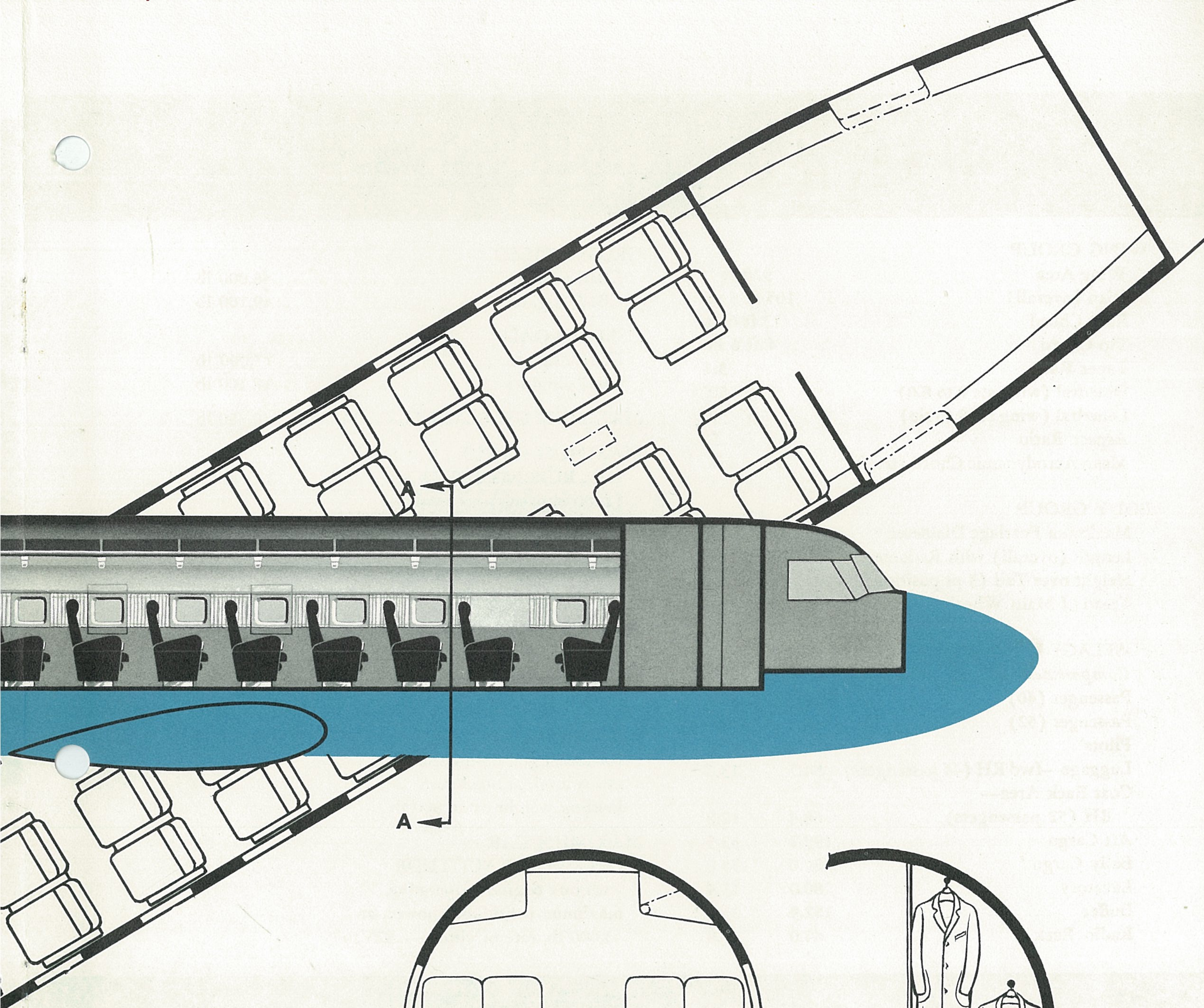
Another feature that further streamlines the nacelle and reduces turbulence during takeoff and climb is the reduction of mid-position cowl door openings from the former two inches top and bottom to a one-inch bottom only, the top cowl doors remaining closed.

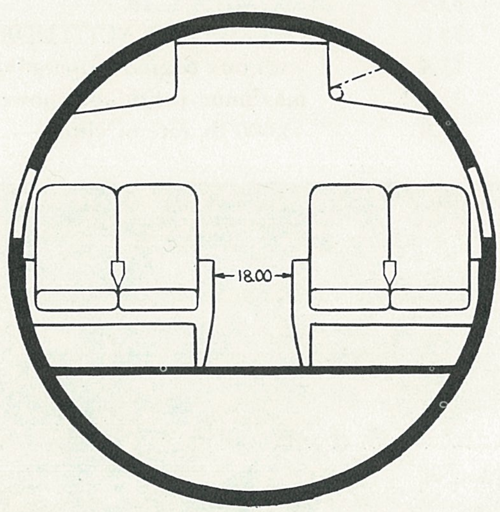
Basically, this is the same orange peel cowling which has been provided both on 240 and 340 aircraft. Maintenance personnel acclaim it the greatest time-saver and maintenance aid ever devised for any aircraft. Because it provides quick accessibility to the power plant installation, it is being adapted to many

(Continued on page 134)

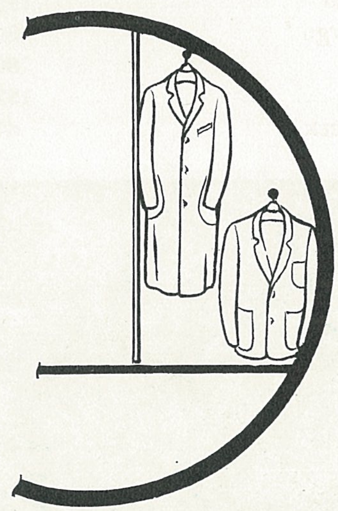
INTERIOR CONFIGURATION







SECTION "A-A"
(LOOKING AFT)



SECTION "B-B"
(LOOKING FORWARD)

CONDENSED SPECIFICATIONS

WING GROUP

Wing Area	920 sq ft
Span (overall)	105 ft 4 in.
Root Chord	13 ft 6 in.
Tip Chord	4 ft 6 in.
Taper Ratio	3:1
Dihedral (wing sta 0 to 8.0)	4° 50′
Dihedral (wing sta 8 to tip)	6° 30′
Aspect Ratio	12
Mean Aerodynamic Chord (true)	9 ft 6.3 in.

BODY GROUP

Maximum Fuselage Diameter	9 ft 5 in.
Length (overall) with Radome	81 ft 6 in.
Height over Tail (3-pt position)	27 ft 9 in.
Tread of Main Wheels	25 ft 0 in.

FUSELAGE VOLUME AND FLOOR AREA

Compartment	*Cu Ft*	*Sq Ft*
Passenger (40)	1816.7	283.4
Passenger (52)	2142.0	334.0
Pilots'	139.5	33.3
Luggage—fwd RH (44 passengers)	84.7	13.6
Coat Rack Area— RH (52 passengers)	68.4	12.8
Aft Cargo	199.2	33.5
Belly Cargo	89.0	55.0
Lavatory	80.0	13.4
Buffet	152.9	23.9
Radio Rack	45.0	7.0

GROSS WEIGHT
CB16 Engines .... 48,000 lb
CB17 Engines .... 49,100 lb

USEFUL LOAD
CB16 Engines .... 17,000 lb
CB17 Engines .... 18,100 lb

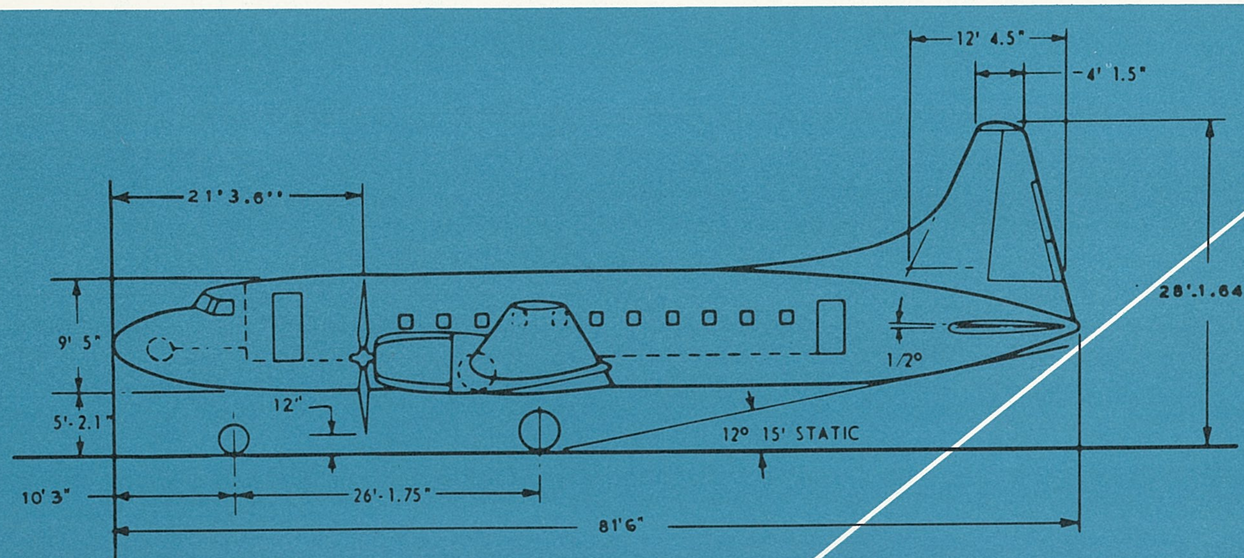
MAXIMUM USABLE FUEL CAPACITY .. 10,380 lb

MAXIMUM RANGE
AT CRUISING SPEED .... 1210 miles
(1200 bhp/eng) no wind,
1500-lb fuel reserve at 20,000 ft,
max takeoff weight (49,100 lb),
44 passengers and baggage,
and 1247 gals fuel

REQUIRED CAR RUNWAY LENGTH 5,000 ft
for takeoff at sea level—
wet rating 2500 bhp/eng
at 49,100 lb

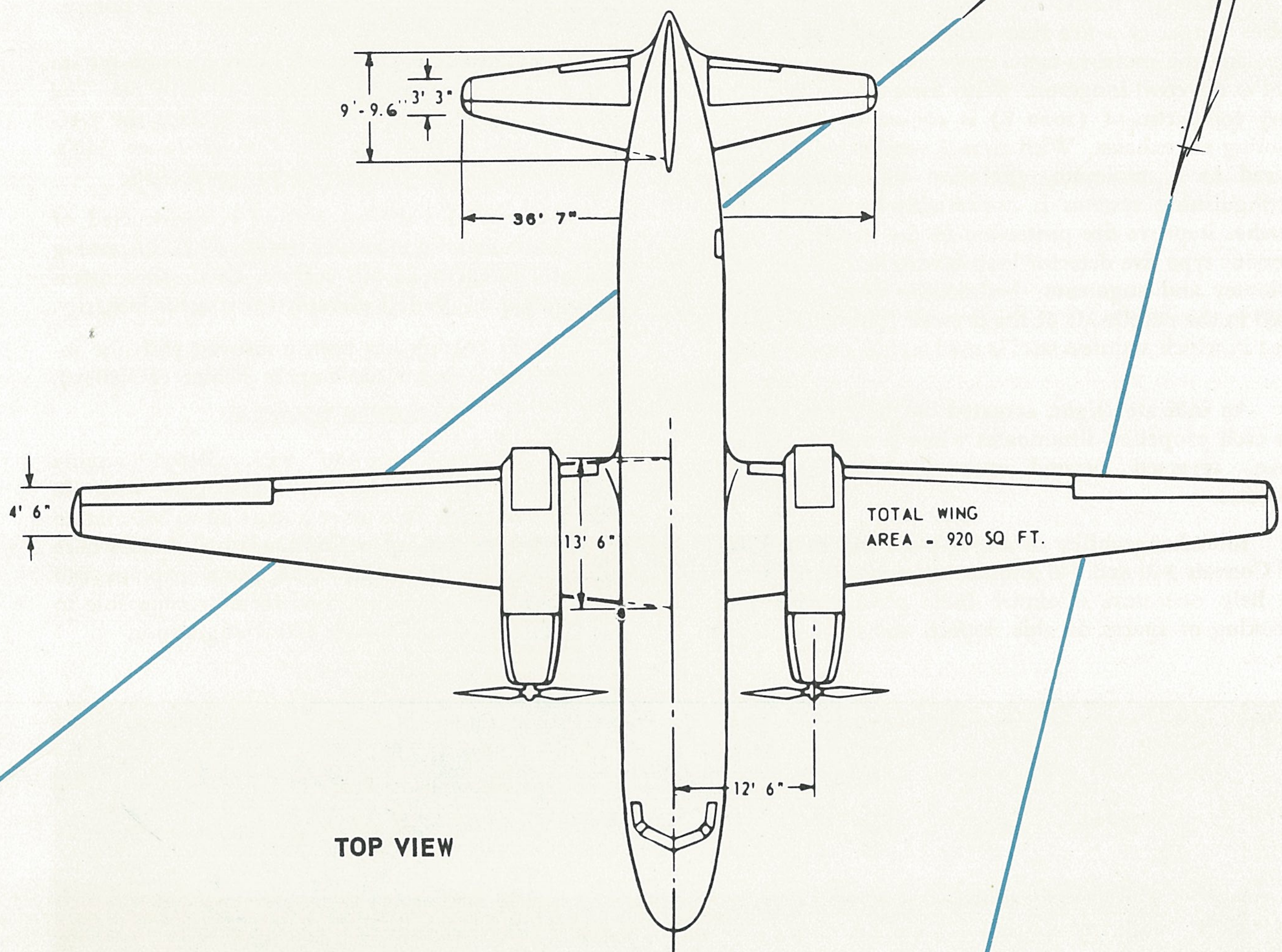
REQUIRED CAR RUNWAY LENGTH 4,010 ft
for landing at destination
at sea level, at maximum
landing weight of 46,800 lb

MAXIMUM CAR
OPERATING ALTITUDE 9,500 ft
with one engine inoperative,
maximum continuous power, at
45,000 lb, rate of climb — $.02V_{so}^2$

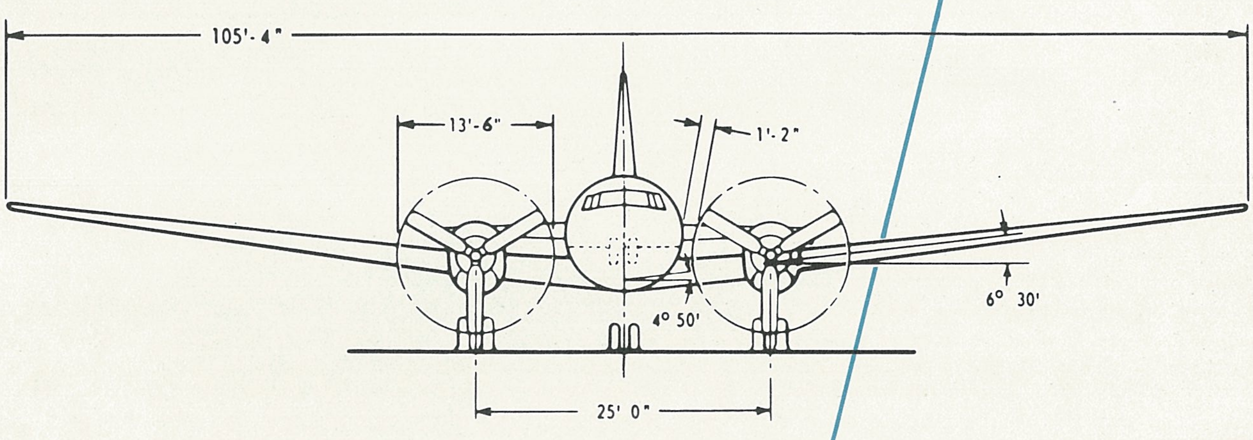


SIDE VIEW

THREE VIEW DRAWINGS



TOP VIEW



FRONT VIEW

military aircraft. Since this cowling is fully cantilevered from the nacelle, it does not vibrate with the engine; consequently, its wear and maintenance are minimized. The four panels of the cowling are attached to the nacelle, even during engine change, thus minimizing handling damage.

An improved method of sealing in the nacelle minimizes danger of a fire spreading. Argo-Sil seals supplement the metal-to-metal seals at the shroud-cowl and at the cowl longeron. With these seals, the accessory compartment (zone 2) is cooled by generator cooling air exhaust. With zone 2 ventilation thus reduced to a minimum, operation of detector and extinguishing systems is appreciably improved. To further improve fire protection in the nacelle, a continuous type fire detector loop is installed in the vent chimney and augmentor bellmouth. Steel skins are used in the nacelle aft of the firewall. This is the same area in which stainless steel is used on late model 340's.

An indicator light, actuated by the blade switch on each propeller, illuminates when propeller blades have reversed beyond approximately the —2° position.

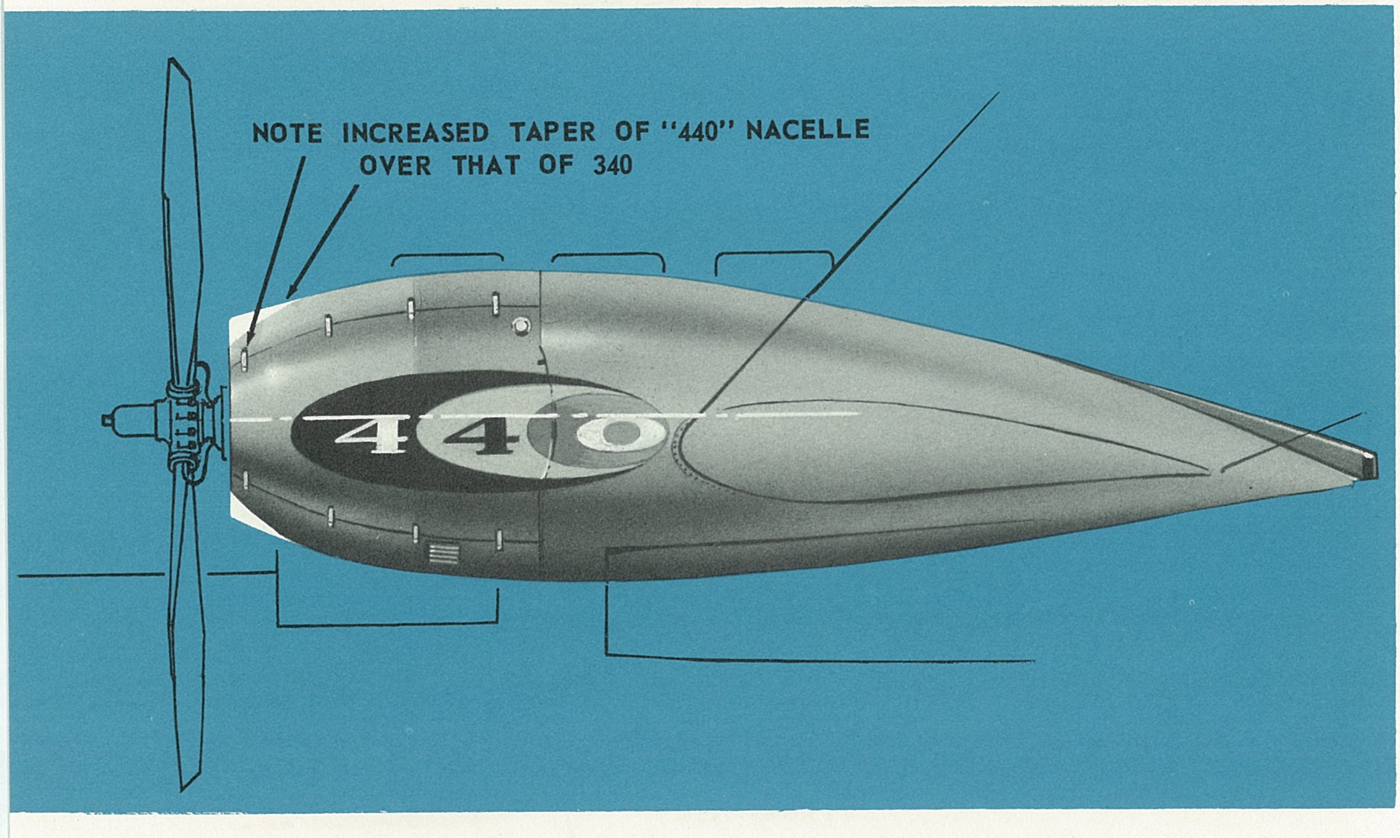
Interchangeability of major parts and assemblies of Convair 340 and 440 aircraft were considered so as to help operators minimize their procurement and stocking of spares. In this respect, and for standardization purposes, two New York Air Brake pumps are installed in the hydraulic system. The NYAB pump (66WA400) installed on the 440 has a slightly larger piston and cylinder bore which replaces displacement in cubic inches per revolution from .593 for the 66WA300 pump on the Convair 340, to .713; however, all other pump parts are interchangeable in aircraft using single or dual variable-delivery pumps.

A pneumatically-controlled cabin pressure system operates on a differential pressure of 4.16 psi. The pneumatic system was designed to replace the electrical control system on late Convair-Liner 340's. Reference: Convair Traveler dated April 1955.

The vertical stabilizer shroud is constructed of honeycomb material to reduce weight while increasing structural integrity of this surface. Dual tab controls are installed on the left elevator for control integrity.

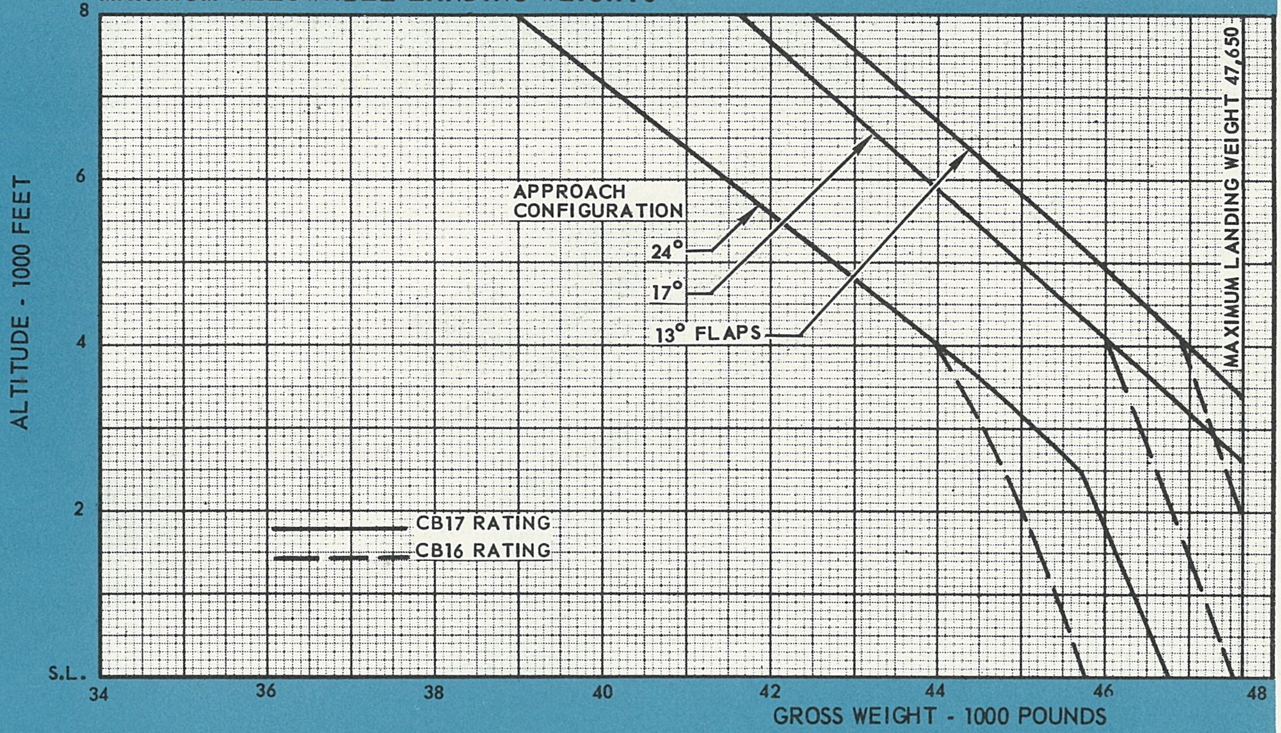
Cockpit heating has been improved with the installation of a Janco 125-ampere heater (PN8030).

The Metropolitan "440" with CB16/17 engine ratings will accommodate 52 passengers with 40 pounds of luggage each on segments up to 850 statute miles, a money-making performance on routes where high density traffic exists. This same airplane can handle long flights with a load factor comparable to that of the standard Convair 340 configuration.

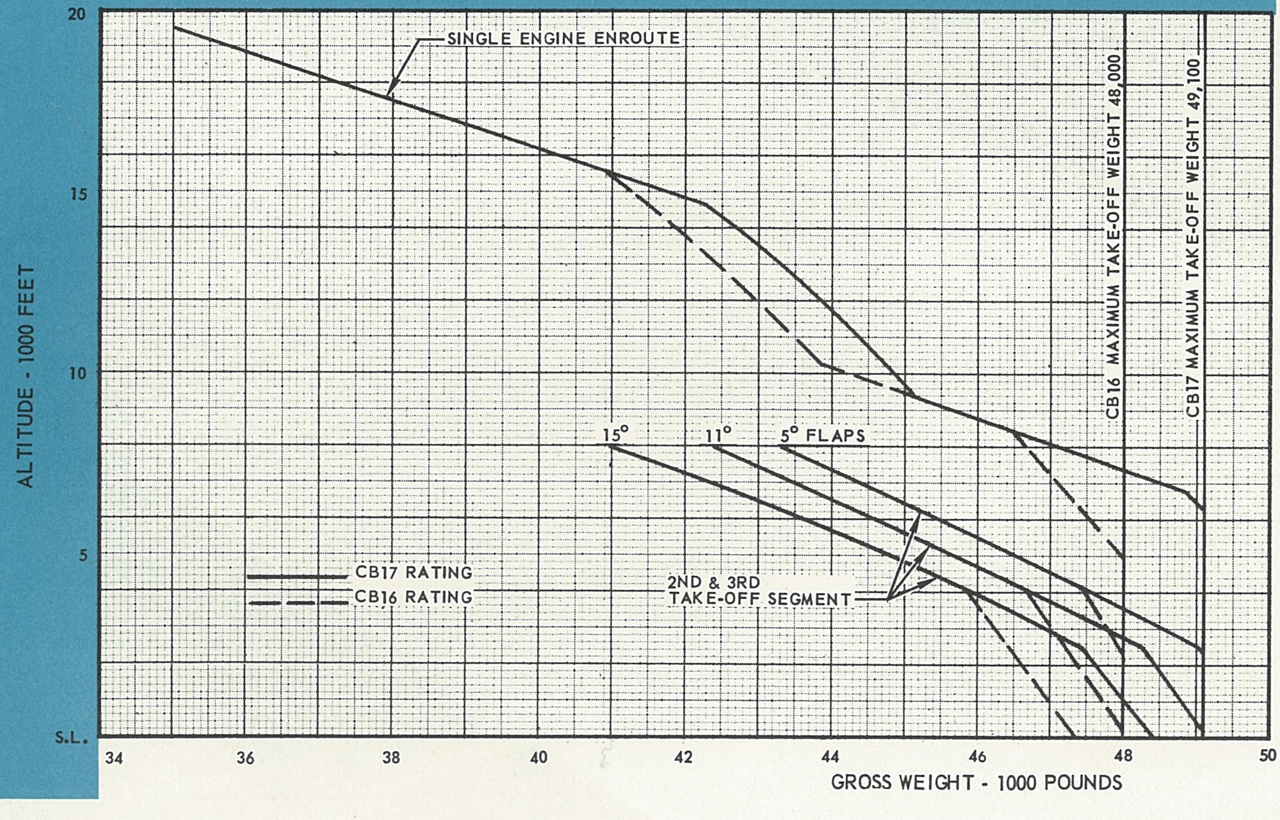


PERFORMANCE DATA

MAXIMUM ALLOWABLE LANDING WEIGHTS



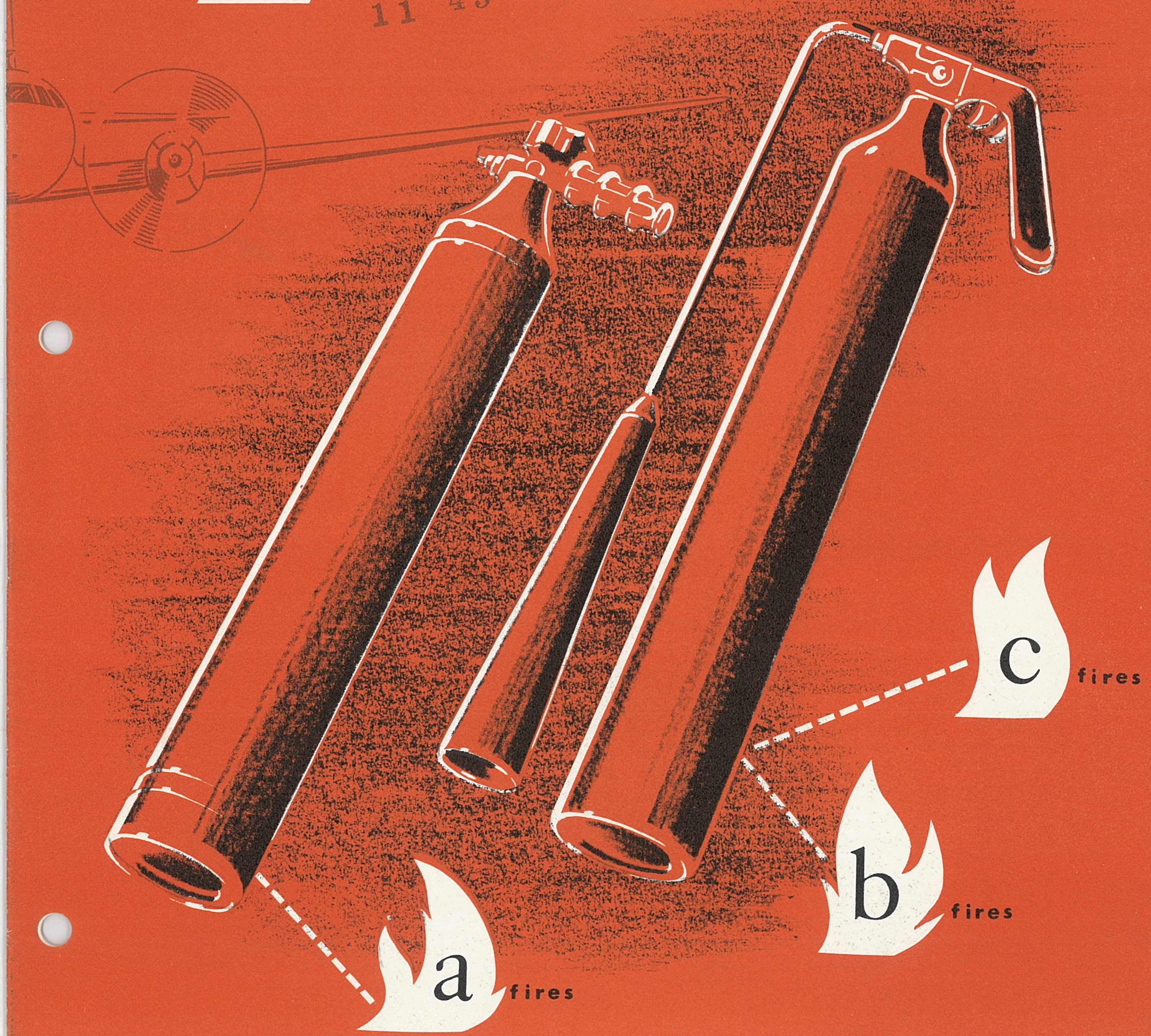
MAXIMUM ALLOWABLE TAKE-OFF WEIGHTS



CONVAIR

Traveler

VOL. VII NO. 12 APRIL 1956



CONVAIR

Traveler

VOL. VII NO. 12 APRIL 1956

FOREWORD

Fire, like many other forces, can be either harmful or useful. The extent of its harmfulness can be limited by the application of a few basic rules of fire fighting. With fire, as with the handling of other natural forces, knowledge is power. Panic and destruction result when knowledge of fire fighting techniques is lacking. In the following pages we attempt to collect some of this know-how under one cover.

THE COVER

On the cover and throughout this issue, artist Bob Sherman stresses the importance of the right type of equipment for extinguishing the three basic types of fires.

CONVAIR
A DIVISION OF GENERAL DYNAMICS CORPORATION
(SAN DIEGO)

A digest of Convair-Liner operation and service published monthly by the Service Publications Section of Convair in the interest of Convair-Liner operators. Communications should be addressed to Chief of Service, Convair, San Diego 12, Calif.

FIRE!

Fire, out of control, wherever it may occur . . . on the ground or in the air . . . may cause loss of life or serious loss of property. Fire, however, may not be the prime cause of loss but rather, panic. Panic, when fires have occurred, causes lack of control and subsequent unfortunate results.

An aircraft is a structure that in itself has little or no tolerance to fire. The designers have recognized this fact and have, in vulnerable areas, provided structures that will withstand or tolerate a certain amount of fire. This design concept is based on the idea that the hazard can be detected and once detected can be controlled. The detection and control means must be reliable, precise, and followed to completion. One has but to examine the year by year record of fires in flight to see that the designers have accomplished the prime objective. Fires are fewer and uncontrolled fires unusual.

Once a fire has started, only calm, proper, and decisive action on the part of crew members will prevent the loss of life and property.

The required techniques, knowledge, and equipment, when properly teamed up with alert personnel will result in maximum efficiency in the combating of aircraft fires.

Since fire strikes so unexpectedly and may travel with great speed, it is important that flight and maintenance crews be trained in fire prevention and fire fighting. When fire occurs, orderly selection of equipment and unquestioned adherence to the procedures on the check-off list are a "must."

In spite of established precautionary measures and constant vigilance, fire can flare into reality, because most fires are caused by simple commonplace failures which are encountered in our daily living.

Control of fires is a matter of knowing what really constitutes a fire, using a calm approach, and applying a few simple measures of precaution.

Three things must be present in order for a fire to start. They are heat, fuel, and oxygen. Remove any one of them and fire cannot exist. Together they are either a potential or an actual hazard.

A thorough understanding of the basic fundamentals of fire and fire extinguishing agents is the first important step in fire prevention. The three principal types of fires are classified as A, B, and C. Extinguishers are also classed A, B, and C. Using the correct type of extinguisher on a fire is of utmost importance. The wrong type may fail not only to extinguish the flame but may cause great personal hazard from electrical shock or poisonous fumes, spreading of fire, or explosion. Extinguishers, therefore, should be of the type most suitable for the class of fire which may occur in the area.

....TYPES of

CLASS A FIRES and EXTINGUISHERS

Class "A" fires are those that occur in common combustibles such as cloth, paper, and wood. They are normally extinguished by cooling. Although at first thought this type of fire may appear to have a rather remote connection with airline operations; such is not the case. There are many cases — and some quite recent ones — of extensive damage caused by this type of fire, not only in hangars and maintenance buildings, but in the aircraft itself.

It is almost impossible to err in extinguishing a Class "A" fire, because any type of fire extinguisher used will do some good and no harm. The most obvious and common of all extinguishing agents is water. Water (H_2O) extinguishers are charged with a gas cartridge to supply a stream or a spray of water that cools burning material below its ignition temperature. It also saturates the material and prevents rekindling. Water spray is especially effective because the resultant steam tends to exclude oxygen from the blaze.

Carbon dioxide (CO_2) is suitable for small surface fires of the Class "A" type. CO_2 is a clean, dry gas that is harmless to foods, fabrics, and fine finishes. It disappears without a trace. This extinguisher is the most commonly used in the home and on aircraft because it offers all-around protection, being suitable for Class "A," "B," and "C" fires. *Care must be exercised when using CO_2 in enclosed areas since it reduces oxygen content of the air.*

It must be kept in mind that carbon dioxide does not *cool* the burning material; it merely excludes oxygen from the fire. Thus, with a Class "A" fire of any size, it is best to use water either during or after the application of CO_2. The same holds true when using carbon tetrachloride.*

Soda-acid type fire extinguishers are essentially the same as the H_2O type, except that instead of using a gas cartridge to provide expulsion pressure, the chemical reaction between the soda and acid is utilized. These extinguishers, being large and relatively heavy, are more common to buildings than to aircraft.

CLASS B FIRES and EXTINGUISHERS

Class "B" fires involve flammable liquids or chemicals, the most common examples being gasoline and oil. These fires are best extinguished by smothering, or excluding oxygen. Class "B" extinguishers may consist of a wide variety of dense heavier-than-air gases, quick vaporizing liquids, powdered chemicals and foam-producing substances.

Water should never be used on a Class "B" fire since it only serves to increase the volume of burning liquid, thus spreading rather than reducing the fire. The possible exception to this rule is the use of fog nozzles, but since these are ordinarily available only to professional firemen, a discussion here would be out of place except to point out that remarkable development of this device has occurred in the last few years.

Carbon dioxide and carbon tetrachloride are the most common agents used in hand fire extinguishers for Class "B" fires. Carbon dioxide type extinguishers emit directly a dense cloud of gas which reduces the oxygen content of the air to a point where it will not support combustion. Carbon tetrachloride extinguishers produce similar results, except that the liquid chemical quenches the fire and turns to a gas when it strikes the blaze. Remember, both should be used with caution in close quarters.

The smothering foam available on many fire trucks consists of a mass of tiny, long-lasting bubbles of CO_2 which are not easily broken down by either agitation or heat. The foam is nothing more than CO_2 mixed with a solution of water and foam liquids to form a continuous mass of bubbles, looking much like whipped cream.

Another class "B" extinguishing agent is sodium bicarbonate (with materials added to produce water repellence and free-flowing characteristics). The chemical breakdown of this material in flame produces CO_2 and water vapor.

***CAUTION CARBON TETRACHLORIDE IS TOXIC AND SHOULD NOT BE USED IN ENCLOSED AREAS.**

FIRES and EXTINGUISHERS

CLASS C FIRES and EXTINGUISHERS

Class "C" fires are those involving electrical equipment and wiring. A non-conductive extinguishing agent is required to prevent injury. For this reason, water should not be used. Carbon dioxide, carbon tetrachloride, and dry chemical extinguishers are all effective for this type of fire. Since the electrical origin of a fire may not be readily apparent, it is wise to check for this possibility before applying a stream of water to any fire in a location adjacent to concealed wires or fixtures.

THE FOLLOWING CHART SUMMARIZES HAND EXTINGUISHING AGENTS FOR USE IN AIRCRAFT AND HANGAR FIRES.

EXTINGUISHER	CLASS "A" FIRES	CLASS "B" FIRES	CLASS "C" FIRES
Types and precautions in their use.	**Paper, wood, cloth, rubbish, etc., where quenching and cooling effect of water is required.**	**Burning liquids such as gasoline, oil, paints, etc., where smothering action is required.**	**Fires in live electrical equipment, such as motors, switches, appliances, where non-conducting agent is required.**
CARBON DIOXIDE (CO_2) *Exercise care when using in confined areas since it reduces oxygen content of air.*	Small surface fires only.	Excellent because it smothers fire. Leaves no residue and does not affect equipment or foodstuffs.	Excellent because it is a non-conductor. Leaves no residue and will not damage equipment.
WATER (H_2O)	Excellent. Water saturates material and prevents rekindling.	*Do not use water because it will spread the fire.*	*Do not use because water is a conductor of electricity.*
CARBON TETRACHLORIDE *Do not use in confined areas.*	Small surface fires only.	Good. Releases heavy gas to quench fire.	Good. Liquid is non-conducting and will not damage equipment.
FOAM	Excellent. Foam has both smothering and wetting action.	Excellent. Blanket of foam floats on top of spilled liquids, smothering the fire. Does not dissipate.	*Do not use because foam is a conductor of electricity and will damage equipment.*
DRY CHEMICAL	Small surface fires only.	Excellent. Chemical absorbs heat and releases smothering gas on fire. Chemical shields operator from heat.	Excellent. Chemical is non-conductor; fog of dry chemical shields operator from heat.

Design for FIRE

The things accomplished in advance afford the best protection during an emergency. Fire prevention and crash survival begin with the design of the airplane . . . with its construction, use of flame-resistant materials, fire detecting and extinguishing systems, isolation of flammable liquids, and numerous other considerations.

In the design of commercial transports, certain minimum standards for maintaining the safety of flight crews and passengers have been established by the Civil Aeronautics Board. Some of the most important considerations are centered around power plant design, oxygen equipment, and fire-resistant materials.

POWER PLANT DESIGN

One of the principal sources of fire in aircraft is in the engine installation. Of all engine fires, approximately 50 per cent are reported to have originated in the exhaust system. The next highest contributors are cylinder and generator failures which account for about 7 per cent each. The remaining 36 per cent are scattered through a multitude of origins which are difficult to classify.

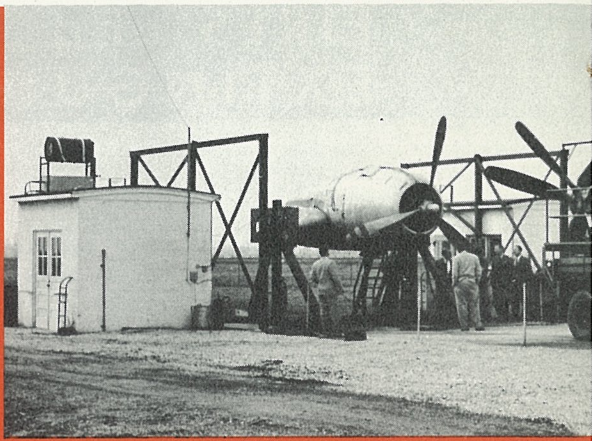
Because the incidence of fire is greater in the power plant section than in other parts of the aircraft, considerable thought has been given to the detection and extinguishment of fire in this area.

Extensive study in power plant fires is being conducted by the CAA Technical Evaluation Center at Indianapolis, Indiana, where a study of power plant fires has been in operation for several years. Fire tests conducted on a full-scale Model 340 nacelle indicated that Convair nacelles have adequate built-in tolerances required for efficient fire control. These studies are designed to improve the prevention, detection, and extinguishing of power plant fires. These three factors — prevention, detection, and extinguishment — actually start with the design of the power plant installation. Following are some of the salient points considered in the design of Convair-Liner power plant installations.

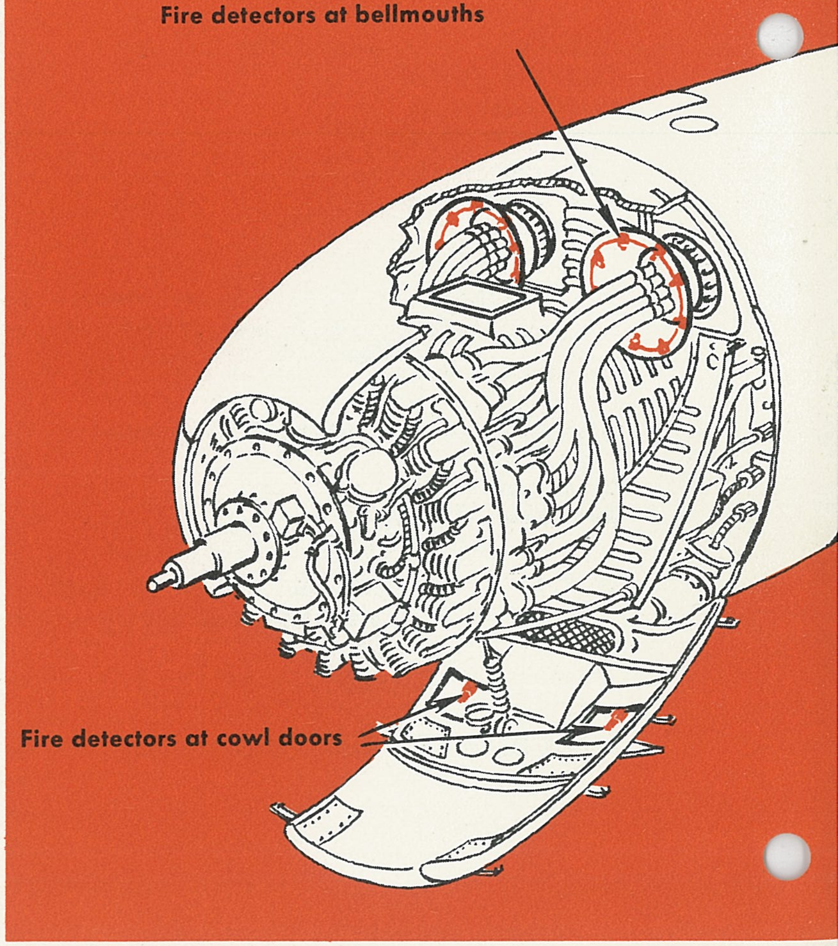
FIRE PREVENTION IN THE POWER PLANT

Stainless steel fire walls prevent the spread of fires and increase the isolation between the nacelle zones in event of a fire. Steel is used in all areas subject to fire and in areas where a fire path could break into other zones.

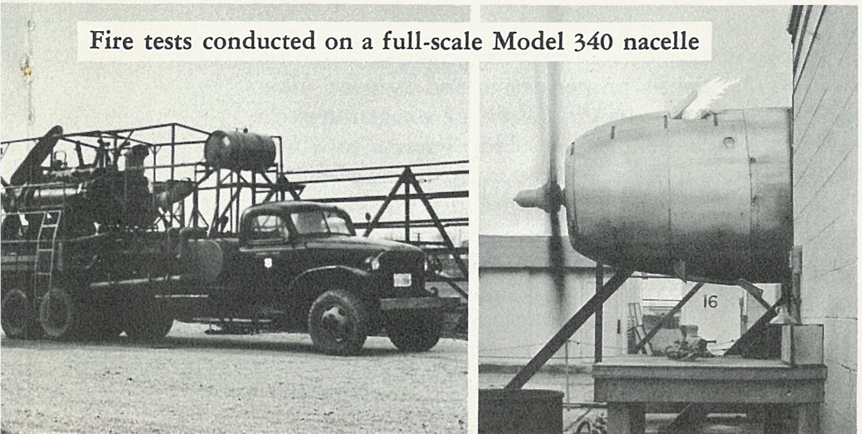
It is always best never to assume that a detector system has rendered a false alarm. There isn't time to look at the affected nacelle to see if there is a fire. Chances are it couldn't be seen anyway, especially during daylight hours. The pilot's reaction must be prompt and accurate in eliminating flow of combustibles to the fire area, and stopping operation of



GENERAL ARRANGEMENT OF CONVAIR 340 TEST NACELLE AND MOBILE AIR BLOWER

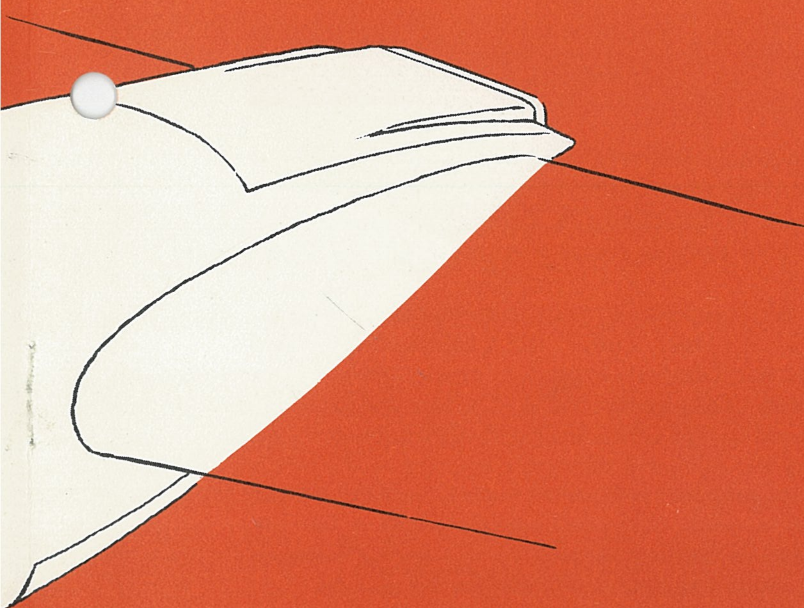


PREVENTION



Fire tests conducted on a full-scale Model 340 nacelle

TEST SHOWING FLAME TRAVEL WITH FULL OPEN COWL DOORS



LOCATION OF FIRE DETECTORS IN "440" NACELLE

the engine. Initiating the fire extinguisher discharge before shutting down the engine doesn't serve any useful purpose. It doesn't pay to try to put out a fire while feeding it.

A fire that is immediately extinguished upon detection may do little or no damage to the engine. A fire that burns for a few minutes may become difficult or impossible to control.

EXTINGUISHING AGENTS FOR POWER PLANT FIRES

Aircraft power plant fire extinguishment is a complex problem because of the many variables involved — the adequate concentration of agent, an effective and suitable extinguishing agent, adequate distribution of agent, adequate duration of concentration and distribution, and prevention of reignition.

Flexible fuel, oil, and hydraulic lines in engine accessories compartment are fire-resistant. Fuel lines in the wheel well have recently been changed to stainless steel; asbestos sleeving has been added to oil hoses to improve their fire resistance. All electrical cables in the engine compartment forward of the fire wall, which are essential to operation during an engine fire, are of approved flame-resistant materials.

Electrical wires to the fire detectors are fire-resistant. They are installed with sufficient length to resist breaking loose from vibration.

Cowling is adequately drained so that fuel and oil cannot accumulate in any part of the structure. Cowl panels fit tightly so as to contain a possible fire.

FIRE DETECTION IN THE POWER PLANT

Fire detection devices are adequately distributed in power plant installations to aid in early discovery of a fire. Proper location of these detectors is important in the detection of fires. Because of the number of flammable fluids in the nacelle, it is difficult to predict where a fire will start, but it is known that wherever the fire starts it will take a certain path to escape the zone. That path is in the air flow outlet. The air outlet areas are completely protected by detectors, which operate on a rate-of-rise principal to detect the flame.

An extinguishing system must provide delivery of an effective agent in sufficient quantity. It should provide an optimum rate of discharge and an optimum distribution of the agent. A deficiency in any one of these primary requirements may cause a system to be ineffective. The use of proper feed line and nozzle sizes is essential to successful extinguishing system design, and successful extinguishment may depend in many instances upon the proper sealing of joints and holes in the nacelle skin or fire walls.

Several power plant fire extinguishing agents are available for satisfactorily controlling fires. Convair 240's use CO_2 which has good extinguishing properties but requires a heavy, high-pressure system. Chlorobromomethane (CB), which is used on Convair 340's, is equal in fire extinguishing ability. However, since the use of space and weight is critical in aircraft, the system that provides the greatest protection per weight and volume is the desired system. CB has the advantage of effecting a weight saving in excess of 150 pounds, plus easy maintenance and serviceability.

Note

Since CB is highly toxic, ground crews and maintenance personnel are cautioned to exercise care in handling cylinders and to avoid breathing fumes.

Under test and evaluation at Convair is a Freon fire extinguishing system for Convair-Liner power plants. This system utilizes a high rate discharge principal to achieve maximum efficiency. When this information is available, it will be forwarded to all Convair-Liner operators.

The fire extinguishing systems on Convair-Liner aircraft afford protection for the accessories compartment (zone 2) and the wheel well (zone 3). A tube is routed directly through the wheel wells to the accessory section of each nacelle. A small line is routed to operate the fire door in the chimney. The accessory section and wheel well distributor rings have closely-spaced orifices to permit the emission of a fine spray of the agent for effective fire extinguishing in all areas of zones 2 and 3.

FLAMMABLE FLUIDS

Investigations of aircraft accidents disclose that a number of fires can be traced to flammable hydraulic fluids. With internal hydraulic pressures up to 3000 psi, leaks emit a fine spray or mist. If ignited, this mist may create a fire or explosion. Ignition may be effected by any hot surface or by a spark from defective electrical equipment.

Convair-Liners are protected from hydraulic fire hazards by design precepts. All hydraulic tubing and installations are separated from electrical wiring and equipment to minimize the danger of fire.

To offset the low flash point of aviation fuels, fuel tanks are constructed to withstand rupture as a result of hard landings and crashes. The integrity of Convair's integral fuel tank has been proved in some crash landings. Even when a wing has been completely severed from the fuselage, there has been no evidence of fire. The relatively short lines between tank and engine also help to minimize the fire hazard.

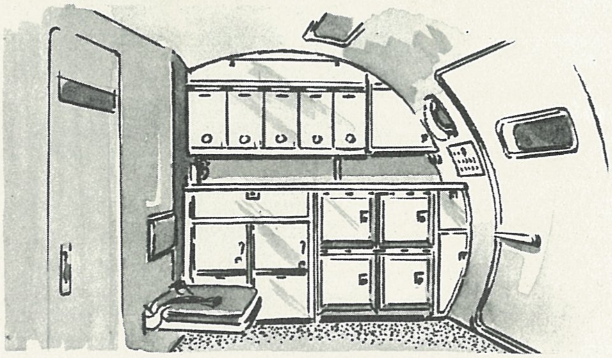
OXYGEN EQUIPMENT

Fire hazards associated with oxygen equipment have been minimized by proper design and by good maintenance practices. In the design of oxygen systems, the engineer keeps oxygen tubing lengths to a minimum to minimize fire hazard in the event of a crash landing, and to reduce the chance of breakage or leakage at joints. High-pressure oxygen cylinders have a reducer at the cylinder outlet to reduce pressure before it is distributed. Whenever possible, oxygen cylinders are installed in a location where danger of explosion on a crash impact will be minimized. Cylinders are located so that they will not be exposed to contamination by grease or oil. All oxygen cylinders are painted green for easy identification. This standardization of color prevents human error in ground and maintenance procedures.

INTERIOR DESIGN

Cabin fires caused by smoking are relatively infrequent. This is, no doubt, in large part a tribute to the alertness of the cabin attendant, but it is also a reflection of the design standards established by CAR.

CAR 4b specifies minimum standards for interior design. All wool, cotton, and synthetic fabrics used in interior trim are treated to render them flame-resistant. Tests conducted at Convair indicate that foam and sponge rubber are highly flammable but that, if they are covered with a flame-resistant fabric which will not support combustion, there is no danger from fire as a result of ignition produced by a burning cigarette or burning paper. All appropriate Convair-Liner interior surfaces are treated in this manner.



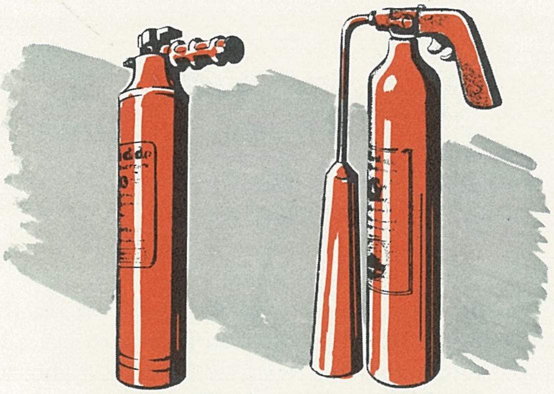
Through thoughtful design, crevices and corners where debris might collect and be ignited by careless handling of a cigarette have been kept at a minimum.

The buffet is constructed of materials that are easy to clean and keep clean. There are no crevices where flammable substances such as grease and oil can accumulate. Reasonably air-tight disposal areas, which will not support combustion, are provided for trash disposal.

All controls for beverage containers are protected by circuit breakers; thus, if a switch pops out to the OFF position, it is an indication that there is an unusual condition in the circuit. If, after resetting, the switch again pops out, the condition still exists and is an indication that further operation of the unit should not be attempted.

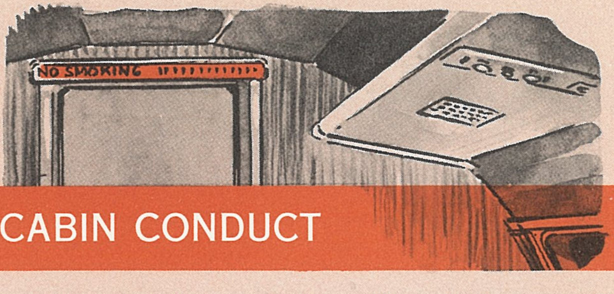
HAND FIRE EXTINGUISHERS

Convair-Liners have a portable CO_2 extinguisher installed adjacent to the cockpit where electrical fires are most likely to occur. It is operated by swinging up the horn (which is attached by a swivel joint), aiming at the base of the fire, and squeezing the pistol grip. Releasing the trigger automatically stops the discharge of gas. In operating any CO_2 type extinguisher, it is well to remember *not* to grasp the discharge horn during operation. The expanding gas creates a very low temperature around the nozzle, and severe frost "burns" can result from contact of the discharge horn with the skin, especially in the excitement of a fire.



WATER (H_2O) EXTINGUISHER **CARBON DIOXIDE (CO_2) EXTINGUISHER**

Water (usually labeled H_2O) type fire extinguishers are located near or in the passenger compartment for putting out paper and cloth fires. Operation consists of turning the carrying handle as far as possible. This action punctures a cartridge of compressed gas which expels the water. The stream lasts from 30 to 45 seconds and has a range of more than 20 feet.



CABIN CONDUCT

CAR regulations prohibit smoking during ground operation, during and immediately after takeoff, immediately before and after landing, and during fueling operations. The pilot may also prohibit smoking during turbulence if he feels that prohibitive action is necessary to prevent possible dropping of lighted cigarettes during turbulent conditions.

The "No Smoking — Fasten Seat Belt" requirement should be exercised whenever the signs are displayed. Passengers should also be cautioned not to smoke if they are taking oxygen or if oxygen is being administered to an adjacent passenger.

Cabin attendants should be alert to paper, match covers, empty cigarette packs, etc., which may be thrown on the floor by passengers. Of importance, too, is the inspection of food trays returned to the buffet. It should be determined that any cigarette butts found on food trays are out, and they should be properly disposed of because they could possibly smolder and cause flame.

Liquid containers should remain approximately one-third full so that there is no danger of boiling them dry. Containers should be pushed back securely against plug connections, because if units jar loose during flight the connection may be broken. The switch should be turned off before removing a hot cup.

Fire extinguishers should be recharged after use, and should be inspected periodically for weight loss.

The use of carbon tetrachloride or CO_2 in any closed area may reduce the oxygen content to a dangerous level. The area should be thoroughly ventilated as soon as is practicable after using this type of extinguisher.

Shallow breathing is a good practice when near any fire in an enclosed area to avoid breathing smoke, heavy extinguishing gases, and other fumes.

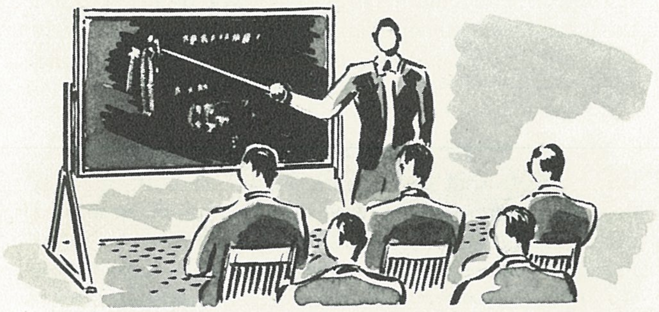
Since airplanes are shut down for many hours of the day, danger is greater at these times because any fire starting then may burn undetected. Many fires from cigarettes start during the first hour after shutdown; hence, inspection should begin immediately after the airplane is evacuated.

Brief Highlights in FIRE PREVENTION and FIRE FIGHTING

The following material is of a general nature and much of it is equally applicable to aircraft, hangar, office, factory, or home. In all phases of fire fighting and fire prevention, the emphasis is on "education."

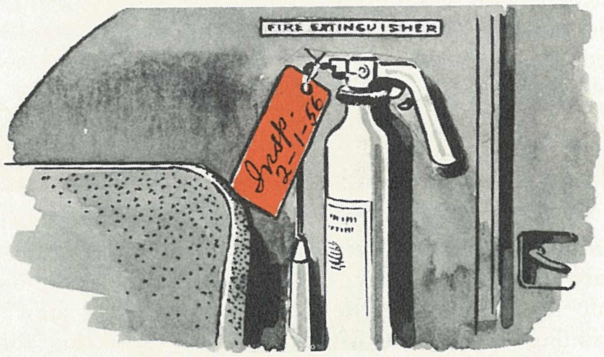
For companies and other organizations desiring to form a Volunteer Fire Department, many state universities sponsor field extensions. Their representatives will, in many cases, conduct courses in fire fighting at the facility requesting them. The presence of a group of trained, organized volunteer firemen within an organization will save valuable seconds and minutes (perhaps lives) in the initial phase of a fire.

All personnel should be aware of common fire hazards and how to avoid them. They should become familiar with "hot spots" and preplan fire fighting techniques of these areas.



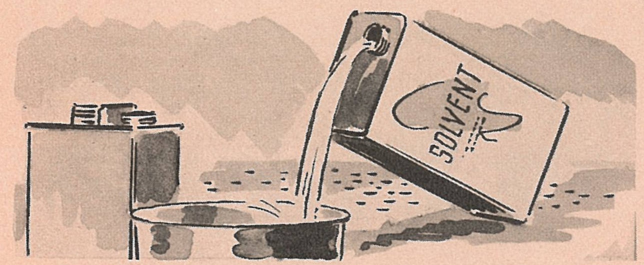
Cautious smoking and the use of matches will eliminate a common cause of fires. Rules regarding smoking should be observed. "No Smoking" signs are there for a purpose. Smoking should not be permitted near flammable materials or gases. "Strike anywhere" matches should be prohibited and at no time should matches be used as flashlights for searching dark areas.

False protection is worse than no protection. Fire extinguishers should be of the type suitable for the kind of fires that may be encountered in an area. H_2O extinguishers in areas of electrical equipment do more harm than good. Extinguishers that are empty or mechanically inoperative may endanger lives of fire fighters who must move in closely to attack a fire. This points up the fact that periodic inspections and maintenance of all fire fighting equipment are important in combating fires. The responsibility for inspecting fire equipment in hangar or aircraft should be the definite responsibility of one individual.



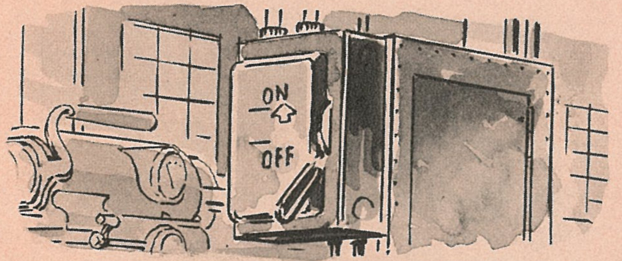
Flammable liquids should never be used in closed areas or anywhere near open flame or sparks. Liquids such as gasoline, benzine, and naphtha give off vapors which are heavier than air and which can flow along the floor to open flame, and flash back to the container.

When pouring thinners and flammable fluids, the metal container should be held so that its spout is at the top of the container when held laterally to the can in which the thinner is poured. This prevents splashing or dribbling. Many kinds of polishes and cleaners contain flammable ingredients. They should be used with the same precautions as gasoline and other flammable liquids — in a well-ventilated area away from the possibility of heat of ignition. It should be remembered that the hazard is in the gases and vapors given off by flammable liquids. Only hammers and tools made of non-sparking materials should be used in places where such fumes occur.



Many fires are the result of inadequate housekeeping practices. Waste disposal, paint storage, and chemical processing are especially significant in this regard. Storage areas should be kept free of rubbish. Since rags containing oils or paints are subject to spontaneous ignition and start fires by themselves, they should be stored in tightly-closed metal cans.

Electricity ranks as an important cause of fire. This is chiefly due to overloaded and short circuits. When a circuit is overloaded or there is a short circuit, the wires get hot. Unless there is a circuit breaker or fuse in the line, a fire may result. A list on the fuse box door should indicate the circuit and the capacity of each fuse. When a fuse blows, it should be located, removed, and all electrical devices disconnected from this circuit. The fuse should be replaced with a new one of the proper capacity. If the fuse blows again, the wiring circuit is "shorted"; if the new fuse does not blow, the previous failure may have been due to a "short" in an appliance or the result of the combined load of all the devices then in the circuit.



When working on electrical circuits, the switch should always be thrown to open the circuit, or the fuse pulled. It should be ascertained that the circuit is dead before removing a broken lamp from a socket. The plug and not the cord should be pulled when disconnecting wires.

The first few minutes . . . we repeat . . . *the first few minutes* are vital in fire fighting if the spread of fire is to be prevented. Unless a person discovering a fire can immediately extinguish it, he should give the alarm at once and get help on the way promptly.

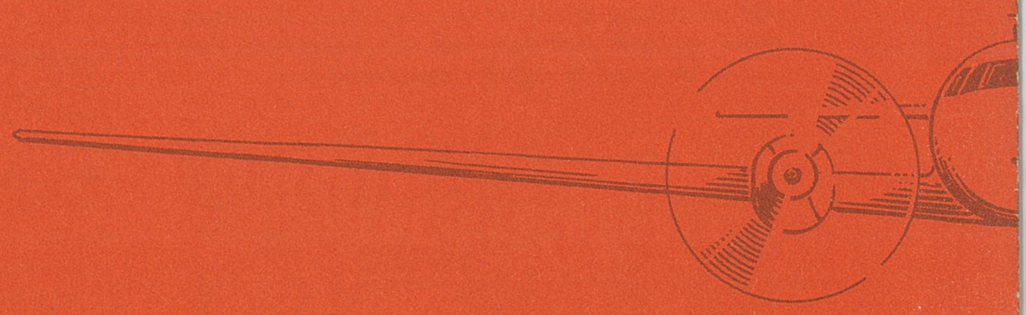
The extension of heat, flame, and smoke into uninvolved areas should be prevented by taking immediate action in the direction the fire is going — not where it has already been. Cooling, ventilating, and air conditioning should be shut down since they contribute to the spread of the fire. Combustibles should be removed from the path of a fire. Doors to any adjacent areas, which may be imperiled, should be closed.

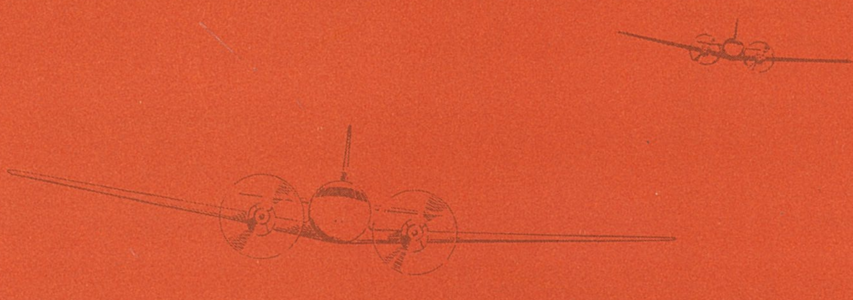
Ventilation of burning areas may prove disastrous; therefore, it should be a decision made by trained firemen. However, should it prove necessary to do so, the areas should be ventilated only after hose lines and extinguishers are in a position to attack the fire. On the other hand, it may be wise to leave a door closed, if the room in which a fire is burning is reasonably airtight, because the fire may extinguish itself through oxygen starvation.

Fire extinguishing agents should be applied to the base of the fire, not to the flames. Although this has been stated many times, it is frequently forgotten by untrained personnel in the excitement of a fire.

A complete wetting down of burned material will insure that there is no danger of rekindling. This is especially important if a Class "B" or "C" type extinguisher has been used on a Class "A" fire.

Remember! When you are betting your life on the proper operation of fire fighting equipment and the knowledge of volunteer fire brigades, it pays to have this equipment in good working order and personnel properly trained to meet the emergency.





CONVAIR A DIVISION OF GENERAL DYNAMICS CORPORATION SAN DIEGO